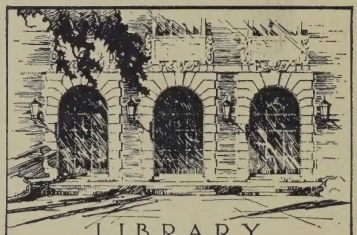
GEOLOGICAL SOCIETY OF LONDON

ABSTRACTS OF THE PROCEEDINGS

1924-25



ABSTRACTS

OF

THE PROCEEDINGS

OF THE

GEOLOGICAL SOCIETY OF LONDON.

SESSION 1924–1925.

Nos. 1123—1138.

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1925.

ABSTRACTS OF THE PROCEEDINGS

OF THE

GEOLOGICAL SOCIETY OF LONDON.

No. 1123.] November 13th, 1924. [Session 1924–25.

November 5th, 1924.

Dr. J. W. Evans, C.B.E., F.R.S., President, in the Chair.

Gerald Andrew, B.Sc., 15 Hawarden Avenue, Whalley Range, Manchester; Harbans Lall Chhibber Bakhshi, M.Sc., Benares Hindu University, F/3 Staff Quarters, Benares (India); Miss Eleanor Violet Colebrook, B.A., B.Sc., 45 Romilly Road West, Cardiff; William Gerald Groves Cooper, B.Sc., Gold Coast Geological Survey, Accra (Gold Coast); Percy Thomas Cox, M.A., 121A Tinakori Road, Wellington (New Zealand); Henry Christopher Curwen, Frenchwood, Arnside (Westmorland); Louis Victor Alfred Fowle, B.Sc., Hurley, St. Alban's Road, Kingston-on-Thames (Surrey); Iowerth Griffith, Assoc.Inst.M.M., Llwynderw, Tregarth, Bangor (Carnarvonshire); Robert Ferrand Paget, F.C.S., Assoc.M. Inst.M.E., 28 Westgate Terrace, S.W. 10; Alan James Ruthven-Murray, B.A., Anglo-Ecuadorian Oilfields Ltd., Santa Elena, Ecuador (South America); Launcelot Potter Timmins, 174 Northfield Road, King's Norton, Birmingham; Thomas Henry Turney, B.A., 6 Harrison Road, Halifax; Walter Frederick Whittard, B.Sc., A.R.C.S., 77 St. Anne's Hill, Wandsworth, S.W. 18; Leslie James Wilmoth, Assoc.Inst.M.M., c/o the British-Burma Petroleum Co., 6 Strand Road, Rangoon (Burma); and Lambodhar Zutshi, B.Sc., 21 Cromwell Road, S.W. 7, were proposed as Fellows of the Society.

The Names of certain Fellows of the Society were read out for the second time, in conformity with the Bye-Laws, Sect. VI, Art. 5, in consequence of the non-payment of the arrears of their Annual Contributions.

The List of Donations to the Library was read; it included, among others, the following works:—Summary of Progress of the

Geological Survey of Great Britain and the Museum of Practical Geology for the year 1923, with Report of the Geological Survey Board and Report of the Director, 1924; Memoirs of the Geological Survey of Scotland—'The Economic Geology of the Central Coalfield of Scotland, Area VI (Bathgate, Wilsontown, and Shotts, &c.)' by M. Macgregor & E. M. Anderson, with contributions by L. W. Hinxman & B. Lightfoot, 1923; Memoirs of the Geological Survey of England and Wales, Explanation of Sheets 318 & 333—'The Geology of the Country near Brighton and Worthing' by H. J. Osborne White, 1924; Explanation of Sheet 108—'The Geology of the Country around Flint, Hawarden, and Caergwrle' by C. B. Wedd, W. B. R. King, & others, 1924; Special Report on the Mineral Resources of Great Britain, vol. xxviii—'Refractory Materials: Fireclays, Analyses and Physical Tests' by F. R. Ennos & Alexander Scott, 1924; Memoirs of the Geological Survey of Ireland—'The Geology of the Ballycastle Coalfield, Co. Antrim' by W. B. Wright, with chapters on the Palæontology of the Field by E. A. Newell Arber & L. B. Smythe, 1924; U.S. Geological Survey, Professional Paper No. 132D—'The Evolution and Disintegration of Matter' by F. W. Clarke, 1924; Geological Survey of South Africa, Memoir No. 22—'A Subject-Index to the Literature on the Geology and Mineral Resources of South Africa' by A. L. Hall, 1924; Carnegie Institution, Publication No. 339—'The Vesuvius Eruption of 1906: Study of a Volcanic Cycle' by F. A. Perret, 1924; Mémoires de la Société de Physique de Genève, vol. xl, pt. 1—'La Détermination des Plagioclases dans les Coupes Minces' by L. Duparc & M. Reinhard, 1924; 'Italian Mountain Geology, Parts I & II—Northern Italy and Tuscany.' Third Edition, by C. S. du Riche Preller, 1924; and 'Études des Gîtes Minéraux de la France—Les Minerais de Fer Oolithique de France, Fascicule II—Minerais de Fer Secondaires' by L. Cayeux, 1922.

Professor Franz Xaver Schaffer of the State Natural History Museum, Vienna, then proceeded to deliver a lecture on The History of the Vienna Basin, of which the following is an abstract:—

After the withdrawal of the sea from Central Europe in Upper Oligocene time the transgression of the Lower Miocene (First Mediterranean Stage) took place along a narrow channel between the foot of the Alpine-Carpathian range and the old Bohemian massif, the sea reaching a height of more than 500 metres above the present sea-level. This narrow channel, which is called the 'extra-alpine basin,' then underwent subsidence, resulting in a fall in the level of the sea during which the so-called Schlier and the beds of Grund were deposited. The latter strata contain the richest subtropical molluscan fauna known in Central Europe. But the appearance of freshwater beds associated with the deposits of this shallow sea shows the interruption of former marine communications towards the west and north.

During the First Mediterranean Stage the region within the Alps, where the 'intra-alpine basin' is now situated, began to subside along two faults running obliquely to the strike of the folds in a north-and-south and north-east and south-west direction. In the triangular depression between them a freshwater lake was formed with its level at first higher than that of the sea without, but was finally invaded by the marine waters carrying a rich fauna (Second Mediterranean Stage). The sea attained a height at this time of about 450 metres above the present sea-level and the subsidence of the floor of this shallow bay continued. A connexion existed at first with the Mediterranean across the Hungarian basin, Serbia, and the Balkan Peninsula, but in the uppermost Miocene a considerable part of this sea was cut off, and an inland sea stretched from Vienna as far as Turkestan. This was the Sarmatian Sea, the brackish waters of which contained a very stunted and uniform fauna, and reached about 400 metres above sea-level.

Then mountain-folding took place in the Transylvanian Alps and the large inland sea was divided into an eastern 'Pontic' and a western 'Pannonian' basin. The water-level of the latter rose to about 450 metres, the freshwater conditions became more accentuated and the fauna still more impoverished (Pontic Stage= Lower Pliocene).

More than 700 metres of sediments were deposited in the intra-alpine basin after the Second Mediterranean Stage, during continued subsidence of its floor. Then by an outflow through the 'Iron Gate' near Orsova a gradual but intermittent sinking of the water-level took place, in accordance with a similar intermittent lowering of the base-level of erosion in the eastern region. Shore-lines have been eroded on the borders of the basin at about 230, 200, 150, 100, and 50 metres above the present river-plain. The predecessor of the Danube had its inflow on the site of the city of Vienna and deepened its channels in accordance with the levels of the lake, depositing gravels over the terraces lying at the above altitudes. With the deposition of the terrace of 50 metres the sedimentation under lacustrine conditions came to an end, and the river eroded the soft sediments and cut lower terraces into them during Quaternary time. Of these terraces only one, that at 15 metres, is preserved within reach of the city.

A Special General Meeting was held at 5.15 p.m. (before the Ordinary General Meeting) to elect a Member of Council and a Vice-President in the room of the late Dr. C. W. Andrews, F.R.S. A ballot was taken, and Sir Arthur Smith Woodward, LL.D., F.R.S., was elected as Member of Council and Vice-President.

The next Meeting of the Society will be held on Wednesday November 19th, 1924, at 5.30 p.m., when the following communi

cation will be read:—'Conditions of Deposition of the Stockdale Shales of the Lake District.' By Prof. J. E. Marr, Sc.D., F.R.S., F.G.S.

George Hulme Hubbard, B.Sc., c/o the Anglo-Persian Oil Company, Ltd., Mohammerah (Persian Gulf); John Joseph Rowe, B.Sc., c/o the Niger Company (Mining Department), Tudun Wadia, Jos (Northern Nigeria); and Benjamin Seymour Redmayne Schofield, B.A., 119 East 19th Street, New York City (U.S.A.), will be balloted for as Fellows of the Society.

At the Meeting on December 3rd, 1924, the following communication will be read:—'A Composite Dyke from Eastern Iceland.' By Miss E. M. Guppy, B.Sc., F.G.S., and L. Hawkes, M.Sc., F.G.S.

No. 318 of the Society's Quarterly Journal, Part 2 of Vol. LXXX, published in July, contains the following papers:—

7. Dr. K. S. Sandford on the River Gravels of the Oxford District.
8. Dr. F. S. Wallis on the Avonian of the Tytherington–Tortworth Wickwar Ridge. (Abstract.)
9. Miss A. E. Bamber on the Avonian of the Western Mendips, from the Cheddar Valley Railway to the Sea, west of Bream Down. (Abstract.)
10. Prof. E. J. Garwood & Miss E. Goodyear on the Lower Carboniferous Succession in the Settle District.
11. Dr. L. J. Wills on the Development of the Severn Valley in the Neighbourhood of Iron-Bridge and Bridgnorth.
12. Mr. C. W. Osman on the Geology of the Northern Border of Dartmoor.

No. 319, Part 3 of Vol. LXXX, now published, contains the following papers:—

13. Sir Arthur Smith Woodward on *Tristychius arcuatus*.
14. Prof. W. S. Boulton on the Breccia-Bed underlying Nechells.
15. Mr. D. J. Farquharson on the Geology of Southern Guernsey.
16. Mr. H. P. Lewis on Upper Viséan Corals of the Genus *Caninia*.
17. Mrs. J. Longstaff on Ordovician and Lower Silurian Gasteropoda from Girvan.
18. Prof. S. H. Reynolds & Dr. E. Greenly on the Geological Structure of the Cleveland–Portishead Area, Somerset.

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ABSTRACTS OF THE PROCEEDINGS

OF THE

GEOLOGICAL SOCIETY OF LONDON.

No. 1124.] **November 26th, 1924.** [Session 1924–25.

November 19th, 1924.

Dr. J. W. Evans, C.B.E., F.R.S., President, in the Chair.

Catherine Mary Lewis, B.Sc., 31 Holland Park Avenue, W. 11; Edgar Francis Newton, B.Sc., 47 Chelmsford Road, Walthamstow, E. 17; and James Watson Reoch, F.Z.S., c/o the Anglo-Persian Oil Company, Ltd., Britannic House, Finsbury Circus, E.C. 2, were proposed as Fellows of the Society.

George Hulme Hubbard, B.Sc., c/o the Anglo-Persian Oil Company, Ltd., Mohammerah (Persian Gulf); John Joseph Rowe, B.Sc., c/o the Niger Company (Mining Department), Tudun Wadia, Jos (Northern Nigeria); and Benjamin Seymour Redmayne Schofield, B.A., 119 East 19th Street, New York City (U.S.A.), were elected Fellows of the Society.

The List of Donations to the Library was read; it included, among others, the following works:—'Lehrbuch der Geologie,' Band iv—'Geologische Formationskunde,' Band ii, 6th & 7th Ed., by E. Kayser, 1924; 'Non-Ferrous Metals & other Minerals,' edited by N. M. Penzer, 1924; Queensland Geological Survey, Publication No. 268—'Industrial Minerals: Salt, Asbestos, Mica, Molybdenite, Platinum, Nickel, Graphite, Manganese, Arsenic,' by B. Dunstan, 1920–21, and Publication No. 273—'Mesozoic Insects of Queensland,' Part 2, by R. J. Tillyard, 1924; 'O Terremoto do 1 de Novembro de 1755 em Portugal e um Estudo Demografico,' vol. ii, by F. L. Pereira de Sousa, 1919; British Antarctic (*Terra Nova*) Expedition, 1910: Natural History Report, Geology, vol. i, No. 6—'The Plutonic & Hypabyssal Rocks of South Victoria Land,' by W. Campbell Smith, 1924; Beiträge zur Geologischen Karte der Schweiz, n. s. lii—'Der Bau der Alpen,' by R. Staub, 1924; 'The East Riding of Yorkshire (with York),' by B. Hobson, 1924; Proceedings of the Royal Irish Academy,

vol. xxxvi, no. 12—'The Glacial Geology of the North-West of Ireland,' by J. K. Charlesworth, 1924; Missouri Bureau of Geology, vol. xvii—'The Devonian of Missouri,' by E. B. Branson, 1922; Bulletins of the United States Geological Survey, nos. 746 & 747—'Geologic Literature on North America, 1785–1918,' by J. M. Nickles, 1923–24; Annual Report of the Ontario Department of Mines, xxx, pt. II—'Ontario Gold Deposits: their Character, Distribution, & Productiveness, 2nd ed., by Percy E. Hopkins, 1924; Memoirs of the Geological Survey of England, Explanation of Sheet No. 239—'The Geology of the Country around Hertford,' by R. L. Sherlock & R. W. Pocock, with contributions by J. Pringle & C. P. Chatwin, 1924; Sheet No. 271—'The Geology of the Country around Dartford,' by Henry Dewey & others, 1924; 'Index Animalium, 1801–1850, Part IV—Index, Bail-Byzos,' by C. D. Sherborn, 1924. Also the following sheets of geological maps—Geological Survey 1-inch map, Sheets 108 (Flint), 138 (Wem), 168 (Birmingham), 239 (Hertford), 271 (Dartford), 318 (Brighton), & 333 (Worthing), 1924; Geological Survey of Scotland, 1-inch map, Sheet 16 (Moffat), 1924.

The President then announced the recent decease of the Society's Foreign Secretary and Past-President, Sir Archibald Geikie, O.M., and made special reference to the great service which he had rendered in familiarizing British geologists with the work of their colleagues in other countries. The Fellows present remained standing during this announcement.

The following communication was read:—

'On the Conditions of Deposition of the Stockdale Shales of the Lake District.' By Prof. John Edward Marr, Sc.D., F.R.S., F.G.S.

A general account of these beds by the late Prof. H. A. Nicholson and the present writer appeared in the Quarterly Journal of the Geological Society in 1888. The conditions of deposition were there alluded to in general terms, and in the present paper an attempt is made to account more fully for their characters.

The deposits are fine muds, of which the mechanically transported matter is essentially similar throughout. The variations are largely due to differences of colour. There are four important varieties: namely, green, grey-to-black, blue, and red. It is maintained that the green muds represent unmodified mechanical sediment, derived from the erosion of igneous and metamorphic rocks. The colouring-matter of the other three varieties is due to carbon and iron sulphide in the grey-to-black, to iron carbonate replacing calcium carbonate in the blue, and to iron oxide in the red muds.

Study of the organisms indicates deposition under quiet conditions. Planktonic and pseudoplanktonic forms occur in the grey-to-black muds, which are graptolitic, and planktonic forms

are also found in some of the other muds. Benthonic organisms are practically absent from the dark graptolitic muds, rare in the green and some of the red muds, and fairly abundant in the blue and part of the red muds. In all cases these benthonic organisms are dwarfed. It is argued that the absence or rarity and dwarf size of benthonic organisms is due to poison.

In the case of the graptolitic muds, it is believed that the poison, which was there most effective, was sulphuretted hydrogen, and in the case of the other muds, varying quantities of iron hydrate. The disturbed upper waters were poison-free, hence a planktonic fauna could exist there, and also a benthonic fauna on the floor of the coastal waters, when that floor was above the 100-fathom line, which is taken as the approximate limit of wave and current action. Such a benthonic fauna is found in the coastal equivalents of the Stockdale Shales away from Lakeland, and the organisms are then not dwarfed. A map is given showing the probable general distribution of the land and water in Western and Central Europe in the Valentian Period, during which the Stockdale Shales were deposited.

Discussion.

Miss G. L. Elles did not think that the conditions were altogether like those of the Black Sea, to which reference had been made, for there must have been free communication with the open ocean in order to let the graptolites get in. She drew attention to the part played by *Zostera* in furnishing the carbonaceous matter in the North Sea, and suggested that the graptolites might have lived attached to some plants, which, like *Zostera*, periodically broke away from their place of growth and were then distributed far and wide by currents; these might well be swept gently into the gulfs and bays, and there come to rest with their living burden.

Prof. O. T. Jones said that they were greatly indebted to the Author for having given them his conclusions as to the mode of deposition of the Stockdale Shales, which he knew so well. Rocks of similar type occur in North Wales, and in passing southwards through Central Wales the Valentian rocks became much thicker and coarser, and showed various evidences of the approach of land in that direction. Changes of the same kind occurred, also, between the Lake District and the South-West of Scotland, and another land-area clearly lay in that direction. The shelly fauna in Wales was apparently restricted during the Lower Valentian, at any rate, to a narrow belt bordering the shore-line, and even then (as at Llandovery) there is a good deal of evidence that the fossils had been drifted from their original habitat. It is possible that drifting would account also for some of the shelly fossils which he found in the Stockdale Shales. The striking changes of colour from dark grey to blue, and from blue to green, which occur in the Stockdale Shales at certain horizons had been observed by the speaker throughout Central Wales when the graptolitic facies is developed, and suggested that they were brought about by

physiographic changes near the shore-lines. It was satisfactory to find that in the Llandovery district, which the speaker had recently examined, there are two well-marked unconformities in the Llandovery formation which are nearly, if not exactly, at the horizons where these changes of colour occur. The speaker was, however, compelled to disagree with the map which the Author exhibited to account for the changes in character of the Valentian rocks. In particular, he would call attention to the facts that in Scandinavia the shelly fauna occurred nearer the Christiania district, and the affinities of these faunas were with those of Girvan, and probably occurred along the same shore-line. The graptolitic faunas lay farther south in Southern Sweden, and were very similar to that of the Stockdale Shales. Still farther south lay the shelly facies of Gotland and Esthonia. Those of Gotland were closely allied to the shelly faunas of the Welsh Borderland, and probably occurred along the same shore-line. The Ordovician and Silurian shelly faunas appear to have been dispersed from the Baltic region along two coast-lines, one passing through the South-West of Scotland and the other through the Welsh borders. There is no evidence that the shelly faunas were able to migrate across the basin of deposition when the graptolitic deposits were accumulating.

The speaker believed that the land-mass of the Midlands was continued towards the Southern Baltic and Esthonia. Westward it ranged nearly east and west through South Wales, and as the north-western coast-line ranged north-east and south-west, the two coast-lines must have approached close to one another. This circumstance may have given rise to an area of deposition having a restricted communication with the open sea which the Author postulated to account for the character of the Stockdale Shales. The South-East of England, Britanny, and the Iberian Peninsula seemed to have formed a different province, in which Upper Valentian graptolitiferous beds lie unconformably on older rocks.

Mr. A. K. Wells compared the lower part of the Stockdale Shales with the Dolgelley Beds of North Wales. The latter also consist of blue and black beds; both are very pyritous, the sulphide having the form of layers of distinct crystals in the lower (blue) beds, but being disseminated throughout the upper (black) beds in a state of fine subdivision. As shown by Prof. Fearnsides in 1905, these rocks owe their intense blackness to their high sulphide content. Thus, lithologically, they are strikingly similar to the black beds in the Stockdale Shales, and after hearing the paper just read, one naturally suspected them of having been formed under 'Black Sea conditions.' The palæontological evidence, however, negatives this possibility, as they contain an abundant benthonic fauna, certain bedding-planes being crowded with trilobites, occasionally entire, but commonly represented by detached cranidia and pygidia, indicating disturbance by bottom currents.

He asked whether the Author would express an opinion on the probable depth of water under which such black pyritous clays were accumulated.

Prof. P. G. H. Boswell welcomed the paper as a valuable addition to knowledge of the constitution of ancient sediments and its influence on the life of the times. The fact that the paper was cautiously speculative was itself a recommendation.

The task which the Author had set himself was no easy one. If the cleaved and altered clayey sediments were excluded, then no more intractable rocks, from the point of view of petrological investigation, could be found in the British geological column than certain of the beds in the Stockdale Shales. New technique was necessary to deal with sediments of this character.

Light on the existence of 'poisonous' conditions might be obtained from the results of recent dredging in the Irish Sea, where black sands and muds, fetid with sulphuretted hydrogen, were being produced. The sediments owed their colour to iron sulphide, the carbonaceous content being practically absent. On exposure to air and consequent oxidation, the material becomes light yellow in colour. In this case no accompanying deposition of calcareous material has been noted.

From the petrological standpoint, the poverty of the Stockdale Shales in those minerals which one might expect to have been derived from crystalline rocks, rather suggested that the detrital material was not obtained at first hand, but was yielded by pre-existing sediments and possibly volcanic material. Only the most stable clayey minerals appear to have survived.

The persistence of grey-green bands, usually unfossiliferous, in the Valentian rocks over wide areas seemed to imply that the conditions obtaining affected a considerable region. Such conditions might be produced by small earth-movements and climatic variations, leading to slight differences in the amount of iron, lime, magnesia, alkalies, silica, or carbon-dioxide dissolved in river-waters and thus brought down into the gulfs. Disturbance of chemical equilibrium, reacting doubtless with chemical changes induced by the lowly marine organisms of the time, might well have resulted in changes in the chemical composition of the fine-grained sediments and their absorbed compounds. Recent investigations served to indicate that some such causes influenced the deposition of calcareous mud, iron oxides and carbonates, felspars, and other minerals on the sea-floor.

Prof. A. H. Cox remarked on the close lithological resemblance between some of the black graptolitic shales and certain beds in other formations, such as the *Avicula contorta* Shales of the Rhætic and the oil-shales in the Lower Carboniferous Rocks of Scotland. Both of these groups occur among strata known to be of shallow-water origin; the Rhætic Series displays all the characteristics of 'lagoon-phase' deposits, while the oil-shales are associated with thick sandstones of shallow-water facies. Arguing by analogy, it would therefore appear probable that the graptolitic shales also represent sediments laid down in shallow water during a period when the supply of sediment was temporarily decreased.

The President remarked on the interest of the employment of

lithological and chemical details in conjunction with palæontological characters to determine the conditions under which the rocks were laid down. He suggested that other Silurian areas (for example, that of North-Western France) might be similarly investigated.

Prof. W. W. Watts also spoke.

The Author, in reply, admitted that the muddy floor and the depth of water had doubtless some influence on the character of the dwarf benthonic fauna. He had no idea as to the actual depth of the water-tracts, but the fact that many of the small trilobites had normal eyes seemed to forbid abyssal conditions. The existence of littoral deposits across Scandinavia in the provinces of Christiania, Östergotland, and Vestergotland, separating areas with black graptolitic shales on the north and south, suggested a land-tract against which the littoral deposits were formed. He did not consider that the mechanical sediments need have been derived directly from igneous and metamorphic rocks.

The next Meeting of the Society will be held on Wednesday, December 3rd, 1924, at 5.30 p.m., when the following communication will be read:—'A Composite Dyke from Eastern Iceland.' By Miss E. M. Guppy, B.Sc., F.G.S., and L. Hawkes, M.Sc., F.G.S.

Gerald Andrew, B.Sc., 15 Hawarden Avenue, Whalley Range, Manchester; Harbans Lall Chhibber Bakhshi, M.Sc., Benares Hindu University, F/3 Staff Quarters, Benares (India); Miss Eleanor Violet Colebrook, B.A., B.Sc., 45 Romilly Road West, Cardiff; William Gerald Groves Cooper, B.Sc., Gold Coast Geological Survey, Accra (Gold Coast); Percy Thomas Cox, M.A., 121A Tinakori Road, Wellington (New Zealand); Henry Christopher Curwen, Frenchwood, Arnside (Westmorland); Louis Victor Alfred Fowle, B.Sc., Hurley, St. Alban's Road, Kingston-on-Thames (Surrey); Iorwerth Griffith, Assoc.Inst.M.M., Llwynderw, Tregarth, Bangor (Carnarvonshire); Robert Ferrand Paget, F.C.S., Assoc.M. Inst.M.E., 28 Westgate Terrace, S.W. 10; Alan James Ruthven-Murray, B.A., Anglo-Ecuadorian Oilfields Ltd., Santa Elena, Ecuador (South America); Launcelot Potter Timmins, 174 Northfield Road, King's Norton, Birmingham; Thomas Henry Turney, B.A., 6 Harrison Road, Halifax; Walter Frederick Whittard, B.Sc., A.R.C.S., 77 St. Anne's Hill, Wandsworth, S.W. 18; Leslie James Wilmoth, Assoc.Inst.M.M., c/o the British-Burma Petroleum Co., 6 Strand Road, Rangoon (Burma); and Lambodhar Zutshi, B.Sc., 21 Cromwell Road, S.W. 7, will be balloted for as Fellows of the Society.

At the Meeting on December 17th, 1924, Dr. J. D. Falconer, M.A., F.G.S., will lecture on 'The Geology of Nigeria.'

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ABSTRACTS OF THE PROCEEDINGS

OF THE

GEOLOGICAL SOCIETY OF LONDON.

No. 1125.] **December 10th, 1924.** [Session 1924–25.

December 3rd, 1924.

Dr. J. W. Evans, C.B.E., F.R.S., President, in the Chair.

Gerald Andrew, B.Sc., 15 Hawarden Avenue, Whalley Range, Manchester; Miss Eleanor Violet Colebrook, B.A., B.Sc., 45 Romilly Road West, Cardiff; William Gerald Groves Cooper, B.Sc., Gold Coast Geological Survey, Accra (Gold Coast); Percy Thomas Cox, M.A., 121A Tinakori Road, Wellington (New Zealand); Henry Christopher Curwen, Frenchwood, Arnside (Westmorland); Louis Victor Alfred Fowle, B.Sc., Hurley, St. Alban's Road, Kingston-on-Thames (Surrey); Iorwerth Griffith, Assoc.Inst.M.M., Llwynderw, Tregarth, Bangor (Carnarvonshire); Robert Ferrand Paget, F.C.S., Assoc.M.Inst.M.E., 28 Westgate Terrace, S.W. 10; Alan James Ruthven-Murray, B.A., Anglo-Ecuadorian Oilfields Ltd., Santa Elena, Ecuador (South America); Launcelot Potter Timmins, 174 Northfield Road, King's Norton, Birmingham; Thomas Henry Turney, B.A., 6 Harrison Road, Halifax; Walter Frederick Whittard, B.Sc., A.R.C.S., 77 St. Anne's Hill, Wandsworth, S.W. 18; Leslie James Wilmoth, Assoc.Inst.M.M., c/o the British-Burma Petroleum Co., 6 Strand Road, Rangoon (Burma); and Lambodhar Zutshi, B.Sc., 21 Cromwell Road, S.W. 7, were elected Fellows of the Society.

The List of Donations to the Library was read; it included, among others, the following works:—New York State Museum, Memoir 16—'The Devonian Crinoids of the State of New York,' by Winifred Goldring, 1923; United States Geological Survey, Professional Paper 127—'The Composition of the Earth's Crust,' by F. W. Clarke & H. S. Washington, 1924: and Bulletin 758—'Bibliography of North American Geology for 1921–1922,' by John M. Nickles, 1924.

The following communication was read:—

'A Composite Dyke from Eastern Iceland.' By Miss Eileen Mary Guppy, B.Sc., F.G.S., and Leonard Hawkes, M.Sc., F.G.S.

The composite dyke cuts the Tertiary plateau-basalts of Breiddal (Eastern Iceland) and in its fullest development comprises seven members, dolerites alternating with quartz-porphyries, the central rock being porphyry.

It is shown that the acid members resulted from one intrusive act, which took place after the intrusions giving rise to the dolerites. From the disposition of the chilled phases it is inferred that the acid magma came up before the middle of the last-formed basic dyke had completely cooled, and an attempt is made to estimate the time which elapsed between the intrusion of the basic and that of the acid magma.

The acid rock is crowded with dolerite-xenoliths. These have a regular distribution, and it is suggested that they originated through the shattering of basic dyke-rock in some other place by explosive action, with incorporation of the fragments in the magma before intrusion into its present position.

The felspar-phenocrysts of the acid rocks are soda-orthoclases with a small optic axial angle, and have a weathered appearance which is ascribed to incipient melting. They are compared with the artificially melted felspars described by A. L. Day & E. T. Allen.[1] Some of the longer felspars are curved, this being considered a mechanical effect due to the flowage of the viscous acid magma.

Xenocrysts of quartz and soda-orthoclase are irregularly distributed through the dolerites. They are similar to the phenocrysts of the acid rocks, and occur in the same relative proportions. It is suggested that their presence in the dolerites is due to the admixture of a small amount of phenocryst-bearing acid magma.

Evidence is cited to show the great viscosity of the acid magma. Possibly it directly overlay a basic magma, which was intruded first because of its greater mobility, and with which small quantities of the overlying acid liquor were drawn off. The final episode was the uprise of the acid residuum with explosive action.

In an Appendix Prof. H. Hilton calculates the probable rates of cooling of the middle and periphery of a dolerite-dyke.

Discussion.

The President thought that it should not be taken for granted that dykes are intruded from below—Dr. Alfred Harker had shown that in many cases magma had flowed horizontally. He considered that the incipient melting of soda-orthoclases would require a higher temperature than that which usually prevailed in minor intrusions, and that this might be explained by oxidation from oxygen in the clastic volcanic rocks into which they were intruded. He thought it probable that in an acid magma rich in volatile constituents

[1] Carnegie Institution of Washington, Publication No. 31, 1905.

quartz and felspar might sink. Experiments on dry melts did not afford evidence to the contrary. The priority of intrusion of the basic magmas might be attributed to the fact that the reservoir was tapped near the base, the acid portion above being rendered extremely viscous at the margin by the loss of volatile constituents. He was glad that the Authors adhered to the view that in the presence of much volatile material, especially water, a silicate magma might separate into two non-miscible magmas, one acid with much water and the other basic with little. He thought that this separation probably had occurred on a large scale at an early stage of the Earth's history, and had been repeated on a smaller scale from time to time since.

Mr. A. K. Wells remarked upon the great interest of the paper, in which the Authors had not attempted to make the facts fit orthodox views on petrogenesis. He thought it possible for the xenoliths to have been of local derivation, as one of the basic dykes had apparently been disrupted by the acid magma. If they had been derived from a deep-seated source, the 'Bowen-Andersen effect' should be noticeable, and the speaker asked whether the 'making-over' of the basic minerals which might be expected had been observed. In the specimens exhibited the xenoliths were particularly clearly outlined, and there seemed to have been no interaction between the solid and the liquid, which would be in accordance with the hypothesis of the explosive formation of dykes. He thought that the Authors had made out a good case for the co-existence of the two magmas in the fluid state in a common magma-basin, and, unless fractional crystallization followed by complete re-fusion were postulated, their facts lead back to the principle of limited miscibility.

Mr. W. Campbell Smith referred to an account written by Mr. E. B. Bailey of a sill near Arthur's Seat, Edinburgh, which, after its upper and lower surfaces had cooled, and after the whole sill had attained a considerable degree of rigidity, had had its central part entirely replaced by a subsequent intrusion of a basaltic magma.[1] He did not think that the presence in the dolerite of xenocrysts of quartz and soda-orthoclase could be regarded as definite proof of the co-existence of the basic and acid magmas in a molten condition. He laid stress on the importance of collecting all the available data of the existence side by side of basic dolerites and acid quartz-porphyries.

Mr. H. G. Smith welcomed the return to the theory of the immiscibility of magmas, and said that pending the arrival of experimental demonstration of its possibility, he was content to accept the evidence supplied by the banded gabbros of Skye. There was no reason to assume the existence of a sharp plane of demarcation between the two liquids in the reservoir; the xenoliths and xenocrysts might be a consequence of imperfect separation As a possible alternative explanation, he suggested that, if the ideas

[1] Trans. Geol. Soc. Edin. vol. xi (1923) pp. 223–29.

recently developed by Dr. H. H. Read were applicable, the xenocrysts found in the dolerite, although now lighter than the enclosing rock, might, in consequence of exchange of constituents, have had at some period a density sufficient to enable them to sink in the magma.

Dr. W. R. Jones congratulated the Authors on their interesting and very suggestive paper, and asked whether they thought that it was at all possible for the doleritic part of the composite dyke to have been formed by the crystallization of the basalt of the country-rock, when narrow layers of basalt became surrounded with intrusive acid magma. If that were possible, then a homogeneous acid magma intruded into a number of narrow parallel fissures could form such a composite dyke as the one described. In this connection, he drew attention to certain lodes in Cornwall which consist of a number of quartz-veins separated one from the other by narrow layers of highly metamorphosed country-rock, which here is killas. A section of one of these lodes had similarities to the section shown of the composite dyke, the quartz and killas of the lode being represented by quartz-porphyry and dolerite respectively, in the dyke. If the chemical compositions of the basalt and the dolerite were alike, or nearly alike, it would be a coincidence not without significance, and he would be glad of information from the Authors on this interesting point.

Mr. Hawkes, replying on behalf of the Authors, said that there was some evidence that the direction of flow of the dyke magmas had a horizontal component, and it was suggested that the movement was from north to south. It was not believed that the flow was solely a lateral one, as the resorption and incipient melting of the intratelluric phenocrysts of the acid rock was assigned to relief of pressure upon intrusion, thus indicating an uprise.

Some of the dolerite-xenoliths in the neighbourhood of the shattered portion of one of the basic dykes were undoubtedly derived in place, but the even thickness of the dolerite-dykes along the greater part of their outcrop was taken as an indication that the xenoliths were not derived from these dykes at the site of their present outcrop.

No interaction between the acid magma and the xenoliths had been detected; but the rare occurrence of reaction-rims round the quartzes of the porphyry was possibly due to basification. The contention that the xenocrysts of the dolerites were derived from a phenocryst-bearing acid magma, and not from quartz-porphyry rock, was based on the absence of quartz-porphyry xenoliths from the dolerites, and the freedom of the euhedral xenocrysts from any attached acid ground-mass.

The Authors had not discussed the origin of the two magmas, but wished to establish the fact of their co-existence.

The field and petrological relationships of the dolerites to the country-rocks did not support Dr. Jones's suggestion regarding their mode of origin.

Rock-specimens and thin sections illustrating the rocks of a composite dyke from Eastern Iceland were exhibited by Miss E. M. Guppy, B.Sc., F.G.S., and L. Hawkes, M.Sc., F.G.S.

The next Meeting of the Society will be held on Wednesday, December 17th, 1924, at 5.30 P.M., when Dr. J. D. Falconer, M.A., F.G.S., Director of the Geological Survey of Nigeria, will deliver a lecture on 'The Geology of Nigeria.'

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ABSTRACTS OF THE PROCEEDINGS

OF THE

GEOLOGICAL SOCIETY OF LONDON.

No. 1126.] **December 22nd, 1924.** [Session 1924-25.

December 17th, 1924.

Dr. J. W. Evans, C.B.E., F.R.S., President, in the Chair.

William Edward Cooke, B.Eng., Lecturer in Mining, Sheffield University, 5 Grange Crescent Road, Sharrow, Sheffield; Janet Mitchell Marr Dingwall, M.A., B.Sc., Assistant-Lecturer in Geology, University College of South Wales & Monmouthshire, 18 Southminster Road, Cardiff; William John Evans, 38 Park Road, Barry (Glamorgan); Arthur Tindell Hopwood, M.Sc., Assistant in the Department of Geology, British Museum (Natural History), Cromwell Road, S.W. 7; Ronald Colgan Jewell, B.Sc., 61 Hornsey Lane, Highgate, N. 6; Gaston Henry Lamarque, A.M.Inst.C.E., 5 Kingsmead Road, Tulse Hill Park, S.W. 2; Arthur Raistrick, M.Sc., Brackenhurst, The Glen, Shipley (Yorkshire); the Rev. Edward Smith, D.D., The Rectory, Chadwell St. Mary, Grays (Essex); Stephen Henry Straw, M.Sc., Lecturer on Geology in the Victoria University, Manchester, Rosegarth, Moss Lane, Bramhall, near Stockport; William Elgin Swinton, B.Sc., Assistant in the Department of Geology, British Museum (Natural History), 19 Gladsmuir Road, Highgate, N. 19; and Frederick William Whitehouse, M.Sc., Sedgwick Museum, Cambridge, were proposed as Fellows of the Society.

Catherine Mary Lewis, B.Sc., 31 Holland Park Avenue, W. 11; Edgar Francis Newton, B.Sc., 47 Chelmsford Road, Walthamstow, E. 17; and James Watson Reoch, c/o the Anglo-Persian Oil Company, Ltd., Britannic House, Finsbury Circus, E.C. 2, were elected Fellows of the Society.

The List of Donations to the Library was read; it included, among others, the following works:—'A History of British Earthquakes', by Charles Davison, 1924 (presented by the

Author); 'The Face of the Earth, vol. v, Indexes & Maps', by E. Suess, translated by Hertha B. C. Sollas, under the direction of W. J. Sollas, 1924; a copy of the lithographed issue on foolscap paper of 'A Memoir & Supplementary Memoir of a Map of the Eastern Branch of the Indus', by A. Burnes, 1828 (presented by R. D. Oldham, F.R.S., F.G.S.); 'A Sketch of the Geological History of the Charophyta', by James Groves & G. R. Bullock-Webster, 1924; Bulletin de la Commission Géologique de Finlande, No. 66—'On Relations between Crustal Movements & Variations of the Sea-Level during Late Quaternary Time, especially in Fennoscandia', by W. Ramsay, 1924; and 'The Authorized Life of Marie C. Stopes', by Aylmer Maude, 1924 (presented by the Author). Also an autographed copy of the late Prof. O. C. Marsh's Monograph on *Odontornithes*, 1880, presented by W. P. D. Stebbing, F.G.S.

Dr. John Downie Falconer, M.A., F.G.S., proceeded to deliver a lecture on the Geology of Nigeria, illustrated by maps and lantern-slides. The lecturer said that the geology of Nigeria has been known in outline for the last ten or fifteen years; but systematic study dates only from the establishment of the Geological Survey in 1919. The Pre-Cambrian rocks consist of quartzites, schists, amphibolites, banded and granitoid gneisses, and foliated and partly foliated granites, pierced by tourmaline-pegmatites which are themselves in places foliated and in places tin-bearing, with the tinstone as a primary constituent. The latest component of the crystalline group is a Younger Intrusive Series, entirely non-foliated and ranging in composition from gabbro to granite, with the latter predominating. There is no evidence for assigning to this series any other than a Pre-Cambrian age. The succession has been from basic to acid, with intrusive rhyolites and quartz-porphyries immediately preceding the granite.

The Younger Granite is rich in soda, and exhibits both a biotitic and a riebeckitic facies, the latter usually local and marginal. After consolidation the granite was broken and fissured, and subjected to pneumatolytic alteration and mineralization with formation of tinstone, topaz, wolframite, blende, and pyrites. The older rocks adjoining the granite were also extensively fractured and broken, and subjected to similar alteration and mineralization contemporaneously with the granite. The pneumatolysis is marked by the complete absence of tourmaline, while tinstone is associated most abundantly with the alteration of the biotitic facies of the granite.

Nigerian tinstone is thus of dual age and origin. It occurs with tourmaline as an original constituent of the older pegmatites and with topaz in the pneumatolytic modifications of the younger granite and surrounding rocks. The granite is by far the richer source, and has shed the larger part of the tinstone which is now being recovered from the alluvial deposits of the tinfields.

The sedimentary rocks of Nigeria consist of Cretaceous and

Tertiary strata, separated by an unconformity. The former have been investigated in the vicinity of the Government colliery, and have been subdivided into four groups, the Lower Shales of marine origin, the Upper Shales of estuarine origin, the Coal Measures, and the Sandstone Group. These groups are in conformable succession, and, despite the occurrence in the Upper Shales of certain plants with Tertiary affinities, they are believed to represent accumulations of Cretaceous age from Turonian upwards.

The Tertiary rocks have been studied along the Eastern Railway between the coalfield and the sea, and have been subdivided into a lower sandstone group, an estuarine group with a middle Eocene fauna (Bende-Ameki beds), a lignite group, and a group of unconsolidated sands and clays (Benin Sands). There is a well-marked unconformity between the Cretaceous and the Tertiary, and it is believed that the various groups of Tertiary rocks are also separated by unconformities. Fossiliferous Tertiary beds have been located in other parts of Nigeria, but the classification established for the Eastern Railway cannot yet be extended to the other Tertiary areas.

The volcanic rocks of Nigeria have been investigated to some extent on the central tinfields, where an older and a younger group have been distinguished. Both are basaltic in character, and the older was subjected to considerable erosion before the effusion of the younger. Ancient river-beds with tin-bearing gravels occur beneath both groups of volcanic rocks.

The next Meeting of the Society will be held on Wednesday, January 7th, 1925, when the following communication will be read:—'The Geology of the Rhobell Fawr District (Merionethshire).' By Alfred Kingsley Wells, M.Sc., F.G.S.

Fellows are requested to send in to the Secretaries, so as to reach them not later than January 6th next, the Names of any Fellows whom they may desire to see placed on the Council.

The Society's Apartments will be closed, on account of the Christmas Holidays, from the evening of Tuesday, December 23rd, 1924, until the morning of Monday, January 5th, 1925.

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ABSTRACTS OF THE PROCEEDINGS

OF THE

GEOLOGICAL SOCIETY OF LONDON.

No. 1127.] January 13th, 1925. [Session 1924–25.

January 7th, 1925.

Dr. J. W. Evans, C.B.E., F.R.S., President, in the Chair.

Richard Eldred Gubbins, A.R.C.S., The Rectory, Prince's Risborough (Buckinghamshire); Robin John Tillyard, M.A., Sc.D., D.Sc., F.L.S., Head of the Biological Department, Cawthron Institute, Nelson (New Zealand); and Margaret Carter Tuck, B.Sc., Woodstreet Farm, Clyffe Pypard, Swindon (Wiltshire), were proposed as Fellows of the Society.

The List of Donations to the Library was read; it included, among others, the following works:—'On the Rock Formations of Novaya Zemlya, with Notes on the Palæozoic Stratigraphy of other Arctic Lands', by O. Holtedahl, 1924; 'Contributions to the Quaternary Geology of Novaya Zemlya', by O. T. Grönlie, 1924; 'Carte Géologique du Congo Belge', by P. Fourmarier, 1924; Bulletin de la Commission Géologique de Finlande, No. 67—'Tracing of Glacial Boulders & its Application in Prospecting', by M. Sauramo, 1924; and U.S. Geological Survey, Professional Paper 92—'The Middle & Upper Eocene Floras of South-Eastern North America' by E. W. Berry, 1924.

The following Fellows, nominated by the Council, were elected Auditors of the Society's Accounts for the preceding year: Henry Dewey and Horace Woollaston Monckton, Treas.L.S.

The following communication was read:—

'The Geology of the Rhobell Fawr District (Merionethshire).' By Alfred Kingsley Wells, M.Sc., F.G.S.

The area described covers some 30 square miles centred about

the mountain-mass of Rhobell Fawr. The succession ranges from low down in the *Lingula* Flags to the Bala Mudstones.

The Cambrian rocks do not differ essentially from their equivalents in the Arthog—Dolgelley and Arenig—Moel Llyfnant districts, although the Tremadoc Beds are less completely developed, not extending far above the *Dictyonema* Band.

A feature of special interest is the development of an igneous cycle at a lower level than anywhere else in North Wales. The Rhobell Volcanic Group comprises an extrusive phase, the products of which were largely pyroclastic in origin and andesitic in composition; and a phase of minor intrusions when sills of hornblende-porphyrite and allied types were injected into the Upper Cambrian rocks in the neighbourhood of the volcanic centre, and dykes of similar composition penetrated the lower rocks of the Harlech Dome. The centre of eruption of which Rhobell is the denuded basal wreck, was a subaërial volcano which became active during the pre-Arenig interval. A further period of erosion was terminated by the transgression of the early Arenig sea, and the rocks of the Basement Group were deposited, these being derived from the denudation of a cone lying some distance east of Rhobell. The higher part of the Ordovician succession is condensed, the Lower Acid Volcanic Group of Cader Idris thins out in the south of the area, the zone of *D. bifidus* is feebly represented, and the *D.-murchisoni* Zone is probably absent. Fossils characteristic of the zone of *Glyptograptus teretiusculus* occur in mudstones at the base of the main volcanic series.

The Llandeilo Volcanic Group, the products of a submarine volcano, present many features of interest. Associated with thick felspar-crystal-tuffs are several flows of pillow-lava. The lowest is a normal basalt varying in texture from variolitic to doleritic, while the remainder are typical spilites. The andesitic magma of Arenig Mountain penetrated only into the extreme north of the area.

Unfossiliferous grey shales, the probable equivalents of the Llyn Cau Mudstones, were laid down during a period of normal sedimentation, during which the magma became more acid, so that the highest volcanic rocks, belonging to the Upper Acid Volcanic Group, include fragmental quartz-keratophyres. The active period of vulcanicity ceased finally and abruptly, the highest volcanic rocks being succeeded by a great thickness of Bala Mudstones.

Basic intrusions are common at several horizons between the Dolgelley Beds and the Upper Acid Group, and are without exception sills. The rocks range from gabbro through gabbroid dolerite, ophitic and subophitic dolerite, to porphyritic and spilitic types scarcely distinguishable from the basic lavas. They are believed to represent the phase of minor intrusions connected with the Llandeilo Volcanic Group. The area provides good illustrations of the action of an intrusive magma in persistently flooding certain horizons and invading selected rocks while leaving others unaffected.

As a consequence of its position at the south-eastern 'corner' of the Harlech Dome, the strike changes almost through a right-angle in passing from south to north. Folding along north-and-south axes is dominant, but the folds have been buckled against the Rhobell mass which acted as a resistant knot lying in advance of the hard core of the Dome. The area is much faulted, the most important dislocations being parallel to those recently described from the Bala district.

Complete chemical analyses of the chief rock-types have been made by Dr. H. F. Harwood.

Discussion.

Prof. W. G. Fearnsides congratulated the Author on his very clear exposition of an interesting and difficult piece of mountain ground, which, although steep and rough, is not everywhere provided with the best of exposures. He thought that the Author's use of the term 'Basement Series' to include the many hundreds of feet of grit, flags, and ashes between the Rhobell volcanic group and the slate exposures which had yielded *Glyptograptus tereti-usculus*, unfortunate.

He accepted the evidence of the great unconformity between the Cambrian (*Lingula* Flags and Tremadoc Slates) and the Rhobell Andesites, but thought that there was in South Wales and the Lake District such good evidence of downward conformity below the *Didymograptus-extensus* Beds (through the zones of *Tetragraptus* and *Dichograptus*) that the Rhobell rocks must be included within the Arenig Series, and that they (and not the beds above the Garth Grit) must be accounted the local base of the Ordovician System.

He agreed that the series of sediments above the Garth Grit can be correlated bed by bed with that developed on Moel Llyfnant and Arenig, and mentioned that he had himself found the characteristic fossils of the *Calymene* Ashes, both in the gorge below Allt Llwyd and on the Rhobell summit-outlier.

He hoped that the Author would look again before concluding that the upper (Llandeilo) volcanic group is newer than the zone of *Nemagraptus gracilis*; and that Llanvirn zones were never deposited in the Rhobell area. Slates with ill-preserved tuning-fork graptolites make quite a show in a stream-course south of the River Wynion, close to the south-eastern corner of the Author's map, and concealment by faulting or under peat is perhaps a more reasonable explanation of their failure to crop out within the area mapped.

The Author had described the later basic intrusions as gabbroid dolerites, although they have few characters in common with plutonic rocks. He has emphasized their frequency as sills at the horizon of the Garth Grit, and argued, therefore, that they must be older than the folding. The speaker suggested that they belonged to the same regional group as the andesitic dolerites of Arenig, and

the great sills which at Tyddyn Dicwn (near Tremadoc) transgress along great thrust-planes all horizons, from the top of the *Lingula* Flags to the *Nemagraptus-gracilis* Zone of the Llandeilo, and have baked rocks which, though uncleaved, had previously been minutely folded.

By reason of its situation, the Rhobell area should afford critical evidence as to the relation of the movements which gave to the Lower Cambrian Slates of the central district of the Harlech Dome their north-and-south cleavage, to those post-Silurian movements which imposed on the rocks of Cader Idris and the Arans their north-east and south-west cleavage, and he hoped that the map when printed would show all the available information concerning the dip and strike of the cleavage within the area mapped.

He welcomed the chemical analyses, and looked forward to the publication of the modern petrographical descriptions of the igneous rocks, which, with the stratigraphy and field evidence, would surely be an important contribution to the geological history of volcanic activity in Wales.

Dr. H. H. Thomas expressed his appreciation of the beautiful piece of mapping that the Author had carried out in a difficult and complicated region. He (the speaker) was particularly interested in the Rhobell Fawr volcanic series for, with Prof. A. H. Cox, he had recently mapped and described in Pembrokeshire a volcanic series which not only reproduced the lithological types of Rhobell Fawr, but undoubtedly occupied an identical geological horizon. In Pembrokeshire this Series (Trefgarn Series) conformably underlay beds with a Dichograptid fauna), and thus, as the Author holds for the Rhobell Fawr series, they occupy a low position in the Arenig. He congratulated the Author on having placed in its proper position in the geological time-scale one more of the Lower Palæozoic volcanic series of Wales.

Prof. O. T. Jones wished to add his congratulations to the Author on having completed so skilfully a very arduous piece of work in a difficult and inaccessible district.

The speaker was of the opinion that the unconformity at the base of the volcanic series was of greater significance than that between the 'Basement Beds' and the volcanic rocks.

It is unlikely that the 'Basement Beds' represent as low an horizon in the Arenig as is represented elsewhere in Britain, while outside Britain, particularly in the Baltic region and in parts of North America, there are strata which are probably somewhat older than any Arenig rocks in Britain. Among such are the Beekmantown limestones of Vermont and elsewhere, which have decided Ordovician affinities. The unconformity between the Ordovician and the Cambrian which appears to occur in every section in Britain is, therefore, of greater significance than has been realized hitherto, and the Author's discovery that the Rhobell Fawr volcanic rocks occupy some portion of the interval between the two systems is, therefore, of great interest.

Dr. E. Greenly drew attention to the fact that, whereas the pebbly grits at the base of the *Extensus* Zone in North Wales are usually of moderate thickness, they expand to a very great thickness in the Tywyn-Trewan district of Anglesey, where shaly films which have yielded a *Tetragraptus* occur about 1200 feet below the shale with *Didymograptus extensus*: this must be the oldest graptolitic fauna yet known in North Wales. It is, therefore, not unlikely that these beds constitute a sedimentary equivalent of the very early Ordovician volcanic series of Rhobell Fawr.

Prof. A. Hubert Cox congratulated the Author on his successful completion of an arduous and difficult investigation. With regard to the similarity of the Rhobell and Trefgarn Series, it is perhaps more than a coincidence that these two volcanic groups, each unique in its own district, should both occur at the south-eastern margins of the greatest Cambrian masses of North and South Wales respectively. The Author's results were of more than local interest: they showed the importance of the interval between the Cambrian and the Ordovician, and helped to elucidate the history of that interval. They possibly furnish a clue to the date of the hornblendic intrusions, ranging from intermediate to ultrabasic, that are so widespread in Cambrian areas as far apart as South Wales, the Midlands, and the Highlands of Scotland.

The information as to the post-Arenig sequence is almost all new. It furnishes further instances of the great stratigraphical variations that seem characteristic of North Wales, and especially of the Dolgelley district, where it is almost impossible to find two mountains on which the whole sequence remains constant. Thus, a traverse in the Arthog district would need 2 miles or more to cross the 3000 feet of strata that separate the Arenig Beds from the *Nemagraptus-gracilis* horizon, whereas the Author has shown that on Rhobell Fawr the corresponding interval is only a few hundred feet. It is one of the anomalies of North Wales that, within the arc of volcanic rocks round the Harlech Dome, distinct groups of great thickness appear and disappear almost magically. It shows how much work remains to be accomplished in linking up the various areas recently resurveyed.

Prof. W. T. Gordon remarked that, although he could not usefully add to the discussion, he could not let the opportunity pass without congratulating his colleague (the Author) upon the successful culmination of a piece of research which had demanded long and patient attention. He had followed the Author's work during its course, and desired to pay tribute to the careful way in which every point had been considered, whether in the field or in the laboratory. The paper, and the discussion which had followed, indicated that the Rhobell-Fawr area was one of considerable interest, not only on account of the local rocks and of the conditions of their accumulation, but because it was a key-area in the elucidation of the general conditions under which the Ordovician strata of North Wales had been formed.

Mr. T. C. Nicholas congratulated the Author on the successful

completion of a very important and arduous piece of work, and upon the interesting and lucid manner in which he had presented his results to the Society. His discovery of the age of the Rhobell Volcanic Group was a notable addition to our scanty knowledge of the events which took place during the interval between the Tremadoc Slates and the base of the Arenig, as developed in North Wales. In Anglesey and in Lleyn, the vast pre-Arenig denudation of the Cambrian beds, so strikingly displayed in the St. Tudwal's Peninsula, showed that this interval was an important one and far greater than would be suggested by the comparatively slight unconformity developed around the Harlech Dome. The speaker agreed with previous contributors to the discussion that the Rhobell Volcanic Group would only fill a small part of this interval, and it was partly in the hope of finding deposits which might bridge the gap that he had some years previously transferred his attention to the Skiddaw Slates of the Lake District. His results were still far from complete; but, while it seemed certain that lower Ordovician horizons occur there than any that are found in North Wales, he was not yet convinced of the existence of any Cambrian beds.

Mr. G. M. Part, in congratulating the Author, also welcomed Prof. Gordon's reference to the more than local significance of this paper. He hoped in reading the details to find inspiration towards solving the Ordovician problems of North-Eastern Pembrokeshire, where the 'Inter-Arenig' suite described by Dr. Thomas & Prof. Cox was followed during later Ordovician times by acid volcanics, spilites, and gabbroid dolerites.

Mr. S. W. Wooldridge said that he had spent a considerable time with the Author on the ground, and had followed the progress of the investigation with the greatest interest. He referred to the difficulties and discomforts which attended such work in a wild and inaccessible country, a factor too often ignored in assessing its value.

He was interested in the marked petrological differences between the Ordovician lavas of Ddu-Allt and Craig-y-Benglog and their presumed time-equivalents at Arenig, only a few miles away to the north. Since no tectonic barrier separated the two areas, the facts acquired a peculiar significance in relation to problems of petrogenesis. It appeared that within the general 'co-magmatic region' of North Wales there were 'petrographic provinces' as clearly marked as those originally described by Judd.

The sediments of the area are of great interest to students of younger rocks. The *Lingula* Flags of Moel Cynwch and Moel Hafod Owen were closely analogous to the familiar Claygate Beds in lithology, when due allowance was made for the great difference in age between the two series. Both series showed the phenomenon of rhythmic banding to advantage, and the same lithological type was found in parts of the Ordovician Basement Series. Such constant and regular sedimentary rhythms were strongly

suggestive of a climatic cause, and it seemed to the speaker that the study of these beds should afford important data to the infant science of palæoclimatology.

He enquired whether the Author had obtained any evidence of the gaseous emanations presumably associated with the Rhobell vent.

The Author expressed his appreciation of the cordial reception of his paper, and of the helpful suggestions made in the discussion. He thought that it would be unwise to substitute 'the Arenig' for the term 'Basement Group', as the latter includes only a portion of the former series. It includes the three lowest members of the succession established in the Arenig Mountain district, but does not include the *Hirundo* Beds, which are also of Arenig age.

In view of the differences of opinion in the delimitation of the Cambrian System by British and Continental geologists, he thought it better to refer to the age of the Rhobell Volcanic group as 'post-Tremadoc' rather than 'post-Cambrian'.

He contended that, compared with the great thickness of the *Bifidus* Beds in South Wales, and their considerable thickness in the Cader Idris country, their development in the Rhobell area could only be described as 'feeble'. Whether this is due to thinning-out or to strike-faulting remains in doubt. He pointed out that the occurrence of the Llanvirn Group at two points outside the area does not prove its occurrence within the area.

The terms 'gabbro', 'dolerite', 'basalt' were used with reference to the size of the grain of the rock, in the sense suggested by the Committee on Petrographic Nomenclature.

He agreed with Prof. Jones that the break beneath the Rhobell mass is the more important of the two, but the identical lithology of the three members of the Basement Group, whether resting upon the volcanic rocks or upon Cambrian slates, proved that a considerable amount of pre-Garth-Grit levelling had taken place. He thought it possible that the highly decomposed state of the rocks of Rhobell, the prevalence of epidotization and pyritization, were the results of alteration dating from the closing phases of the volcanic episode.

He regretted that there was not sufficient time to discuss adequately the petrological differences between the rocks of Arenig and those of Cader Idris. He had convinced himself that the differences are real, and probably resulted from differences in stress conditions and in the conditions of outpouring at the two independent centres of eruption. Submarine conditions, coupled with long-continued depression, had impressed a spilitic character upon the magma of the Cader Idris centre, while the normal andesites of Arenig Mountain might be correlated with relative elevation of the district and subaërial eruptions.

Rock-specimens, microscopic sections, and fossils were exhibited by Mr. A. K. Wells, in illustration of his paper.

The next Meeting of the Society will be held on Wednesday, January 21st, 1925, at 5.30 P.M., when Prof. Leon W. Collet, For.Corresp.G.S., will give a synopsis of 'Recent Views on Alpine Tectonics', illustrated by lantern-slides.

William Edward Cooke, B.Eng., Lecturer in Mining, Sheffield University, 5 Grange Crescent Road, Sharrow, Sheffield; Janet Mitchell Marr Dingwall, M.A., B.Sc., Assistant-Lecturer in Geology, University College of South Wales & Monmouthshire, 18 Southminster Road, Cardiff; William John Evans, 38 Park Road, Barry (Glamorgan); Arthur Tindell Hopwood, M.Sc., Assistant in the Department of Geology, British Museum (Natural History), Cromwell Road, S.W. 7; Ronald Colgan Jewell, B.Sc., 61 Hornsey Lane, Highgate, N. 6; Gaston Henry Lamarque. A.M.Inst.C.E., 5 Kingsmead Road, Tulse Hill Park, S.W. 2; Arthur Raistrick, M.Sc., Brackenhurst, The Glen, Shipley (Yorkshire); the Rev. Edward Smith, D.D., The Rectory, Chadwell St. Mary, Grays (Essex); Stephen Henry Straw, M.Sc., Lecturer on Geology in the Victoria University, Manchester, Rosegarth, Moss Lane, Bramhall, near Stockport; William Elgin Swinton, B.Sc., Assistant in the Department of Geology, British Museum (Natural History), 19 Gladsmuir Road, Highgate, N. 19; and Frederick William Whitehouse, M.Sc., Sedgwick Museum, Cambridge, will be balloted for as Fellows of the Society.

The forthcoming number of the Quarterly Journal, No. 320, Part 4 of Vol. LXXX for 1924, contains the following papers:—

19. Mr. W. B. Wright on the Age and Origin of the Lough Neagh Clays.
20. Dr. A. Heard & Mr. R. Davies on the Old Red Sandstone of the Cardiff District.
21. Dr. H. H. Thomas & Prof. A. H. Cox on the Volcanic Series of Trefgarn Roch, & Ambleston (Pembrokeshire).
22. Mr. L. Hawkes on an Olivine-Dacite in the Tertiary Volcanic Series of Eastern Iceland.
23. Prof. O. T. Jones on the Upper Towy Drainage-System.

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ABSTRACTS OF THE PROCEEDINGS

OF THE

GEOLOGICAL SOCIETY OF LONDON.

No. 1128.] **January 29th, 1925.** [Session 1924–25.

January 21st, 1925.

Dr. J. W. Evans, C.B.E., F.R.S., President, in the Chair.

Cecil Edward Redmill, B.Sc., 3 Manby Grove, Stratford, E. 15, was proposed as a Fellow of the Society.

William Edward Cooke, B.Eng., Lecturer in Mining, Sheffield University, 5 Grange Crescent Road, Sharrow, Sheffield; Janet Mitchell Marr Dingwall, M.A., B.Sc., Assistant-Lecturer in Geology, University College of South Wales & Monmouthshire, 18 Southminster Road, Cardiff; William John Evans, 38 Park Road, Barry (Glamorgan); Arthur Tindell Hopwood, M.Sc., Assistant in the Department of Geology, British Museum (Natural History), Cromwell Road, S.W. 7; Ronald Colgan Jewell, B.Sc., 61 Hornsey Lane, Highgate, N. 6; Gaston Henry Lamarque. A.M.Inst.C.E., 5 Kingsmead Road, Tulse Hill Park, S.W. 2; Arthur Raistrick, M.Sc., Brackenhurst, The Glen, Shipley (Yorkshire); the Rev. Edward Smith, D.D., The Rectory, Chadwell St. Mary, Grays (Essex); Stephen Henry Straw, M.Sc., Lecturer on Geology in the Victoria University, Manchester, Rosegarth, Moss Lane, Bramhall, near Stockport; William Elgin Swinton, B.Sc., Assistant in the Department of Geology, British Museum (Natural History), 19 Gladsmuir Road, Highgate, N. 19; and Frederick William Whitehouse, M.Sc., Sedgwick Museum, Cambridge, were elected Fellows of the Society.

The List of Donations to the Library was read; it included, among others, the following works:—Memoirs of the Geological Survey, Scotland—'Tertiary & Post-Tertiary Geology of Mull, Loch Aline, & Oban: with Petrology & Palæobotany' 1924;

'Outlines of the Occurrence & Geology of Petroleum', by I. A. Stigand, 1925, with an Appendix on 'Geographical Methods as applied to Oil-finding', by M. Mühlberg; Bulletin of the National Research Council, No. 36: 'Catalogue of Published Bibliographies in Geology, 1896–1920', compiled by E. B. Matthews, 1923; 'Les Roches Eruptives de la Serbie', by J. M. Zujovič, 1924; 'Evolução da Estructura da Terra & Geologia do Brazil', by A. Betim Paes Leme, 1924; and 'The Geology of Singapore Island: with a Geological Sketch-Map', by J. B. Scrivenor, 1924.

The PRESIDENT then announced the recent decease of the Society's Past-President, WILLIAM WHITAKER, F.R.S., and referred to his long and eminent scientific career, to his abounding good-nature, and his kindness to all with whom he came into contact. The Fellows present remained standing during this announcement.

Dr. LÉON W. COLLET, For. Corr. G.S., Professor of Geology and Dean of the Faculty of Science, University of Geneva, proceeded to deliver a lecture on 'The Latest Ideas on the Formation of the Alpine Range.'

In 1905 Prof. E. Argand determined in the Pennine Alps the existence of six great recumbent folds or nappes. He started from the notion of the geosyncline, so splendidly developed by Dr. E. Haug, and destined to remain for all time the basal conception of tectonics. His equipment included a very detailed stratigraphical knowledge, and, armed with this, he has succeeded in straightening out the recumbent folds, and in thus reconstituting the Pennine region at various stages of its development, when the general geosynclinal depression was subdivided by geanticlinal ridges.

On the base of Argand's results Dr. R. Staub found in the north-eastern part of the Swiss Alps the same tectonic elements, covered by six higher nappes belonging more to the type of the 'thrust-masses' of the North-Western Highlands of Scotland than to the type of the recumbent folds of the Pennine Alps. This new series of nappes has been named by Staub the Austrides, for they form the main part of the Austrian Alps.

For many years the Austrian geologists regarded the Tauern as a gneissic massif surrounded by schists and shales. Lately Prof. L. Kober, of the University of Vienna, has recognized instead a window: that is, a horizontal cut, due to erosion, in the nappes of the Austrides, which reveals deeper nappes belonging to the Pennine series. Therefore, this discovery shows that the nappes of the Austrides have been thrust over the Pennine nappes in the Austrian Alps, just as in the north-eastern part of Switzerland.

This was excellent, but a satisfactory co-ordination of the work done by Austrian and Swiss geologists was needed. That was accomplished at the end of last year by Dr. Staub. He published

a memoir on the formation of the whole Alpine chain, from the French Alps to the Austrian, including the Swiss Alps, and summarized his views in a splendid geological map.

A capital point is the employment of Wegener's ideas on the drifting of continental masses, to explain the movement of the Hinterland towards the Foreland of the geosyncline. Foreland and Hinterland constitute the boundaries of the great Alpine geosyncline: together they recall the two jaws of a vice. Prof. P. Termier, Director of the French Geological Survey, has shown how the approach of the two jaws has led to the compression of the geosyncline, and thus to the development of the Alpine chain. Prof. Argand, at the Session of the International Geological Congress in Brussels, showed that the nappes of the Austrides belong to the Hinterland: that is, to Africa or Gondwanaland. Therefore the Austrides, with the Préalpes, represent a small part of Africa resting on Europe or Eurasia. These important views are accepted by Dr. Staub and by the Lecturer. Alpine tectonics are a great support to Wegener's theory on the drifting of continental masses.

The Lecturer presented the results arrived at, with the help of an enlargement of Dr. Staub's geological map, drawn by his Assistants for this lecture and others that he had arranged to give at the University of Cambridge, at the University College of Wales, Aberystwyth, and to the Geological Society of Edinburgh.

At the end of the lecture Prof. Collet showed lantern-slides with views of the Pennine Alps (to illustrate Argand's standard work) and views of the Mont Blanc Massif, where he has been working in recent years with his collaborators, Prof. Reinhard and Dr. Parejas.

The next Ordinary General Meeting of the Society will be held on Wednesday, February 4th, 1925, at 5.30 P.M., when the following communication will be read:—'The Petrology of the District between Nevin and Clynnog-fawr (Carnarvonshire)'. By Dr. Albert Heard, M.Sc., F.G.S.

Richard Eldred Gubbins, A.R.C.S., The Rectory, Prince's Risborough (Buckinghamshire); Robin John Tillyard, M.A., Sc.D., D.Sc., F.L.S., Head of the Biological Department, Cawthron Institute, Nelson (New Zealand); and Margaret Carter Tuck, B.Sc., Woodstreet Farm, Clyffe Pypard, Swindon (Wiltshire), will be balloted for as Fellows of the Society.

The Annual General Meeting of the Society will take place on Friday, February 20th, at 3 p.m. The Fellows and their friends will dine together at the Café Royal, on the same evening, at 7.15 for 7.30 p.m.

No. 320 of the Society's Quarterly Journal, Part 4 of Vol. LXXX for 1924, now issued, contains the following papers:—

19. Mr. W. B. Wright on the Age and Origin of the Lough Neagh Clays.
20. Dr. A. Heard & Mr. R. Davies on the Old Red Sandstone of the Cardiff District.
21. Dr. H. H. Thomas & Prof. A. H. Cox on the Volcanic Series of Trefgarn, Roch, & Ambleston (Pembrokeshire).
22. Mr. L. Hawkes on an Olivine-Dacite in the Tertiary Volcanic Series of Eastern Iceland.
23. Prof. O. T. Jones on the Upper Towy Drainage-System

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ABSTRACTS OF THE PROCEEDINGS

OF THE

GEOLOGICAL SOCIETY OF LONDON.

No. 1129.] **February 11th, 1925.** [Session 1924–25.

February 4th, 1925.

Dr. J. W. Evans, C.B.E., F.R.S., President, in the Chair.

Charles Weatheritt Scott, B.Sc., M.I.M.E., H.M. Junior Inspector of Mines, Leybourne House, Regent Street, Stoke-on-Trent, was proposed as a Fellow of the Society.

Richard Eldred Gubbins, A.R.C.S., The Rectory, Prince's Risborough (Buckinghamshire); Robin John Tillyard, M.A., Sc.D., D.Sc., F.L.S., Head of the Biological Department, Cawthron Institute, Nelson (New Zealand); and Margaret Carter Tuck, B.Sc., Woodstreet Farm, Clyffe Pypard, Swindon (Wiltshire), were elected Fellows of the Society.

The List of Donations to the Library was read; it included, among others, the following works:—'Les Lacs', by L. W. Collet, 1925; Memoirs of the Geological Survey of Scotland: 'The Pre-Tertiary Geology of Mull, Loch Aline, & Oban', by G. W. Lee & E. B. Bailey, with contributions by S. S. Buckman & H. H. Thomas, 1925; Special Reports on the Mineral Resources of Great Britain, vol. viii: 'Iron Ores—Hæmatites of West Cumberland, Lancashire, & the Lake District', 2nd ed., by Bernard Smith, 1924; 'Reports on the Geology of St. Kitts, Nevis, & Anguilla, B.W.I.', by K. W. Earle, n.d.; Journal of the Washington Academy of Sciences, vol. xiv—'The Distribution of Iron in Meteorites & in the Earth', by L. H. Adams & H. S. Washington; 'The Radial Distribution of Certain Elements in the Earth', by H. S. Washington; 'Temperatures at Moderate Depths within the Earth', by L. H. Adams, 1924; 'Outline of the Mineral Resources of the Gold Coast, with Hints on Prospecting', by A. E. Kitson, 1925; and 'Notice Historique sur Alphonse Milne Edwards', by A. Lacroix, 1924.

The following communication was read:—

'The Petrology of the District between Nevin and Clynnog-fawr (Carnarvonshire).' By Albert Heard, M.Sc., Ph.D., F.G.S.

The area described occupies about 30 square miles of the northern portion of the Lleyn peninsula, and is situate between the small towns of Nevin and Clynnog-fawr.

Drift obscures most of the valleys, and conceals the greater part of the areas underlain by unaltered shales.

Most of the sedimentary rocks consist of dark purplish-grey shales of *Didymograptus-bifidus* age, together with their metamorphosed representatives.

In the north-western part of the area unfossiliferous pale-grey shales are present. These shales contain numerous ashy and fine-grained gritty bands, and occur immediately above the *D.-bifidus* Beds,

The pisolitic iron-ores of Trwyn-y-Tal, which appear to occupy the same stratigraphical horizon as the pale-grey shales, are described. These ores are greatly deformed mechanically. Their possible origin by bacterial agency is discussed.

A large proportion of the exposed rocks consists of an igneous complex of post-Lower Arenig—pre-Old Red Sandstone age.

The intrusive rocks present many petrological variations, including numerous different types of granite and quartz-porphyries, granophyres, porphyries of intermediate composition, and basic rocks.

Andesites, with spilitic affinities, occur in the south-eastern portion of the district. They are interbedded with sedimentary rocks, and have a flow-breccia at the base.

Nodular rhyolites, with much included jasper, occur in the north of the area, and are characterized by large felspar-phenocrysts. They are petrologically unlike any known Ordovician lavas. These porphyritic rhyolites appear to underlie the *Didymograptus-bifidus* Beds, but the strata upon which they rest are not exposed. Their age is a matter of conjecture; it is concluded that they represent either Pre-Cambrian extrusives, or Arenig lavas poured over a Pre-Cambrian floor.

The invaded sedimentary rocks exhibit almost every stage of thermal metamorphism: the greatest degree of alteration has resulted in the formation of a fine-grained garnet-sericite-schist.

One of the most interesting of the many petrogenetical problems which have arisen during the investigation is associated with the peculiar 'banding' of the constituents of the coarser-grained intrusive masses. Several excellent exposures of the junctions of these bands reveal the fact that neither hybridism nor any apparent chilling is exhibited at the junction of adjacent 'bands'. Moreover, the uppermost band invariably consists of the most basic rock.

Discussion.

Mr. A. F. Hallimond remarked upon the interest attaching to the occurrence of pisolitic iron-ore. Dr. R. L. Sherlock had drawn attention to the occurrence of both red and black ores at other localities in North Wales. It would be of interest to know more definitely the nature of the black mineral in this type of ore, as the analyses generally suggest that it is a form of ferric oxide, and not magnetite. He presumed that the evidence for bacterial origin now offered was of similar character to that put forward by A. O. Hayes in his detailed account of the iron-ore of Bell Island (Newfoundland). In this connexion, it was necessary to bear in mind that the fact of a deposit being riddled by boring organisms did not necessarily prove that these organisms originated the deposition of the iron. The iron-secreting bacteria, or algæ—for the organisms had been described under the two names by different authors—formed only a very small section of the micro-organisms with which the sea-floor doubtless teemed during the deposition of the iron-ores; and it was at least equally probable that an important part was played by bacteria which did not contain iron, and of which no trace remained in the geological record. Peculiar vermicular forms were also assumed by ferric oxide in the Cheadle ironstone and in the Carboniferous hæmatite-ores. The former gives evidence of contemporaneous formation, for the particles are interbedded in clay; but the latter are usually regarded as definitely secondary. Great care must, therefore, be used in assigning an organic origin to these peculiar felted structures. Perhaps the best example of the North Welsh ores was the bed at Llandegai, with which the deposit now described seems to present considerable similarity.

Mr. W. Campbell Smith said that everyone would regret the absence of Dr. Harker, who in 1889 had described many of the rocks with which the Author had dealt.

He thought that in petrographic work of the kind which the Author was doing it was most important to try and find what rocks in other areas were comparable with those under consideration. He asked whether the rhyolites which the Author had described were in any way related to the rhyolites described by Dr. Harker in the neighbourhood of Pwllheli and Llanbedrog. The basic intrusions at Pen-y-rhiwiau were doubtless similar to the 'hornblende-diabase' and 'hornblende-picrite' of Mynydd Penarfynydd in the south of the Lleyn Peninsula. The rocks of both localities had been described by Dr. Harker.

With regard to the banded structure described by the Author, in what appeared to him to be single intrusions, and in which the upper bands consisted of rock more basic than that of the lower bands, the speaker was glad to learn that the Author was undertaking a geochemical investigation of this problem. He thought that, before any explanation such as the Author had offered was put forward, the observations in the field which the Author had made with such care should be supported by all possible data that

could be obtained regarding the mineral and chemical composition and the densities of the rocks.

Mr. L. Hawkes expressed the hope that the Author would not, without very careful consideration, rule out the possibility that the 'banding' of the composite masses had resulted from successive intrusion. The absence of chilled margins to the bands was not conclusive, for such margins were not always present in cases in which successive intrusion was obvious. He did not think that the position of the basic band at the top presented any special difficulty, as this was a common feature of many composite sills, in which the later acid magma had penetrated beneath, or in the middle of, an already holocrystalline (but possibly still hot) basic sill.

The President emphasized the importance of determinations of density and chemical analyses. Brögger and others had drawn attention to the early crystallizing of basic minerals at the cooling surface of the magma, usually the upper surface; but he doubted whether this explained the relations described by the Author in the present case.

The Author, in reply, expressed his interest in Mr. Hallimond's account of pisolitic iron-ore deposits.

He deprecated the destructive criticism advanced by Mr. Campbell Smith. The present paper was intended to be a purely descriptive petrological work. The Author had stressed the problem of the 'banding', in the hope that a constructive criticism might be advanced that would assist him in subsequent work on these petrogenetical problems. He does not intend to advance any definite theory, until he can produce full geochemical and physical evidence in support.

The Author did not agree with Mr. Campbell Smith that newly-described rocks should, and could, be always compared with similar known types. In his opinion, chemical analyses were the only satisfactory means of establishing a relationship.

He had examined many of the rocks of the Lleyn which were mapped as Ordovician rhyolites, but had found none that were similar to those of Bron-y-Miod.

He thanked the President for his valuable suggestions, and for drawing attention to the fact that the occurrence of the most basic band at the top of a magma was suggested by Prof. W C. Brögger's work.

The Author agreed with Mr. Hawkes that one would like to suggest a theory of successive intrusions to account for the banding; but the field evidence appeared to militate against the adoption of such a theory in connexion with these Lleyn intrusions.

Models of twenty-two famous diamonds were exhibited by the Rev. H. N. Hutchinson, M.A., F.G.S.

The next Ordinary General Meeting of the Society will be held on Wednesday, February 25th, 1925, at 5.30 P.M., when the following communications will be read:—

1. 'The Geology of Cader Idris (Merionethshire)'. By Prof. A. H. Cox, D.Sc., Ph.D., F.G.S.
2. 'The Dissection of Pitching Folds'. By Prof. A. H. Cox, D.Sc., Ph.D., F.G.S.

Cecil Edward Redmill, B.Sc., 3 Manby Grove, Stratford, E. 15, will be balloted for as a Fellow of the Society.

The Annual General Meeting of the Society will take place on Friday, February 20th, at 3 p.m. The Fellows and their friends will dine together at the Café Royal on the same evening at 7.15 for 7.30 p.m.

No. 320 of the Society's Quarterly Journal, Part 4 of Vol. LXXX for 1924, now issued, contains the following papers:—

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ABSTRACTS OF THE PROCEEDINGS

OF THE

GEOLOGICAL SOCIETY OF LONDON.

No. 1130.] March 5th, 1925. [Session 1924–25.

Annual General Meeting.

February 20th, 1925.—Dr. John William Evans, C.B.E., F.R.S., President, in the Chair.

The Reports of the Council and the Library Committee, proofs of which had been previously distributed to the Fellows, were read. It was stated that, of the 53 Fellows elected in 1924 (10 more than in 1923), 42 paid their Admission Fees before the end of that year, making, with 10 previously elected Fellows and 1 re-instated Fellow, a total accession of 53 in the course of 1924. During the same period, the losses by death, resignation, and removal amounted to 49, and there was thus an increase of 4 in the number of Fellows (as compared with a decrease of 3 in 1923).

The total Receipts from all ordinary sources of income, including also the interest on the Sorby and Hudleston Bequests and the interest transferred from the Prestwich and Barlow-Jameson Funds, amounted to £4270 4*s.* 4*d.*, and the Expenditure to £4156 9*s.* 9*d.* The year opened with a deficit of £63 12*s.* 11*d.*, and closed with a balance in hand of £50 1*s.* 8*d.*

The completion of Vol. LXXX of the Quarterly Journal was announced.

The Reports having been received, the President presented the Wollaston Medal to George William Lamplugh, F.R.S., addressing him as follows:—

Mr. Lamplugh,—

It is with the greatest pleasure—a pleasure which is, I am sure, shared by the Fellows generally—that I hand to you the

Wollaston Medal, the highest honour that it is in the power of the Society to award. When you received the Bigsby Medal in 1901, you were already widely known by your work on the Cretaceous rocks and the Glacial deposits of the North of England. Your work on the Isle of Man was then on the eve of publication: it proved to be a mine of original observations on glacial phenomena and rock-structures, especially crush-conglomerates. You have since added still further to our knowledge of the Mesozoic formations, and have assisted, in no small measure, in the just interpretation of the evidences of glacial action in this country. In a widely different sphere you have studied the erosion of the Batoka Gorge of the Zambezi, and there are innumerable other problems of Stratigraphical and Dynamical Geology that you have illuminated in the course of your long and varied experience as a member of the Geological Survey. But, perhaps, your most original contribution to our science was the enunciation, in your Presidential Address of 1919, of the important principle that the present outcrops of formations coincide more or less closely with the tracts in which they attained their greatest original thickness.

Mr. Lamplugh replied in the following words:—

Mr. President,—

I am proud indeed to be admitted to the rank of the Wollaston Medallists, and I ask you, Sir, to convey my thanks to the Council for this treasured distinction.

On the previous occasion to which you have referred, the Council awarded to me an honour which was partly anticipatory in its terms, and was handed to me by the President with an expression of trust. Conscious as I now am how far below intention my achievement has been and must be, it is with the deepest gratification that I receive this Medal as a token that the Council has taken a favourable view of the work done, as well as of the intention.

May I also thank you, Sir, personally, for your appreciation of my work?

The President then presented the Murchison Medal to Dr. Herbert Henry Thomas, M.A., addressing him as follows:—

Dr. Thomas,—

It is difficult to summarize in a few words your services to our science, for which I now hand to you the Murchison Medal. Your most striking contributions have been to our knowledge of the mineral contents of sedimentary rocks, which have yielded valuable information concerning their origin. As Petrographer to the Geological Survey, you have contributed again and again to the successful issue of its labours. I should like to stress, more

especially, your work on the igneous and the sedimentary rocks of South Wales, and that on the Tertiary minor intrusions of the Island of Mull. Nor should we forget the interesting memoir in which you traced the origin of the extraneous rocks of Stonehenge to the hills of Pembrokeshire. I must not conclude without a reference to the great debt which the Society owes to you, for your untiring devotion to its interests during your long term of office as its Secretary.

Dr. Thomas replied in the following words:—

Mr. President,—

I am deeply sensible of the great honour that the Council of the Society has conferred upon me in awarding to me the Murchison Medal, and in thus adding my name to a list so long and of recipients so worthy.

For me, as a geologist with wide sympathies, and more particularly as a petrologist, it greatly enhances my gratification to receive the Medal at your hands, and I thank you personally for the graceful words with which you have accompanied the award.

To every right-minded man, expressions and tokens of approval are extremely precious; but it is on occasions such as these that he realizes how great is his debt to his friends and colleagues, and how little his position is due to his own inherent qualities or effort.

To my dear friend and teacher, Prof. Marr, I owe more than mere words can express; and in the same connexion I should be ungrateful if I failed to acknowledge the great educational benefits that I received by working in close co-operation with Prof. Sollas during the three years that I was privileged to act as his assistant at Oxford, a period to which I may refer as my 'geological adolescence'.

The honour that the Council has conferred upon me will stimulate me, if incentive be needed, to further endeavour in the cause of our Science, and I trust that I may never fail to mete out to others such kindly help and encouragement as it has ever been my own good fortune to receive.

In presenting the Lyell Medal to John Frederick Norman Green, B.A., the President addressed him as follows:—

Mr. Green,—

In awarding to you the Lyell Medal, the Council recognizes you as a worthy representative of the great succession of non-professional geologists who have done so much for the science in this country. In your work on the ancient rocks of St. David's you were able to present a clear interpretation of a much-debated area. This was followed by no less important investigations in the Lake

District, while your recent contributions to the difficult problems presented by the Pre-Cambrian rocks of the West of Scotland are fresh in the memory of us all. As an official of one of our great Government Departments, you have, I need not say, always borne in mind the value of scientific research in promoting the well-being of all classes.

Mr. Green replied in the following words:—

Mr. President,—

It has been more by luck than purpose that my researches have led me among the most beautiful scenes of our lovely country. But if, in the course of these happy wanderings, while striving to learn something of the architecture of the hills, I have been so fortunate as to add a stone to the noble building of British Geology, it has been due to the kindly advice and assistance of my professional friends, particularly Mr. George Barrow, by whose encouragement I was brought to attempt geological work. It gives me great pleasure to know that Prof. Marr, to whose teaching I owe so much, was himself a recipient of the Lyell Medal; and also to take it from the hands of one with whom I have often been associated in promoting investigation of the remoter lands of the Empire.

The President then handed the Bigsby Medal, awarded to Cyril Workman Knight, to Mr. Lucien Pacaud, Permanent Secretary, Canadian High Commissioner's Office, for transmission to the recipient, addressing him as follows:—

Mr. Pacaud,—

It is with the greatest pleasure that the Council of the Geological Society have awarded the Bigsby Medal, founded by Dr. J. J. Bigsby, a distinguished Canadian geologist, to Mr. Cyril W. Knight.

It is impossible within the limits of time available to me on this occasion to enumerate all the claims that Mr. Knight possesses to our recognition. In co-operation with Prof. William Campbell, he developed the study of ores by the examination of polished surfaces. In the Pre-Cambrian rocks of South-Eastern Ontario he was able to demonstrate that the Hastings Series lies unconformably on the Grenville, a question which has been in dispute since the time of Logan. His work on the underground geology of the Sudbury and Cobalt areas was a worthy sequel to that of Dr. Miller, who it was that, a few days before his death, did a last service to this Society in supplying us with particulars of Mr. Knight's achievements.

In awarding this Medal to Mr. Knight, the Council take the opportunity of recognizing the splendid contributions to Geological Science made by our Canadian comrades.

Mr. Pacaud replied in the following words:—

Mr. President,—

May I be permitted, as my first word, to convey to you the Canadian High Commissioner's deep regret at being unable to accept, owing to a previous engagement, your most kind invitation? Mr. Larkin has asked me to represent him to-day, and in the fulfilment of this very pleasant mission, I feel that no word of mine could better express the thoughts and feelings of Mr. Knight, than to hasten to offer to you on his behalf his warmest thanks for the high honour which you have so kindly bestowed upon him on this occasion.

In awarding to Mr. Knight the Bigsby Medal, founded by a distinguished Canadian, you have shown your appreciation of his valuable contributions to geological research, and I know that I am interpreting the feelings of all Canadians in assuring you that they will all share in this well-merited recognition which has thus crowned the efforts of their eminent fellow-countryman.

In forwarding this Medal to Mr. Knight, I will not fail to let him know the kind words that you have uttered, Sir, words which I know will be received by him with pride and with gratitude.

In presenting the Balance of the Proceeds of the Wollaston Donation Fund to Dr. Alfred Brammall, the President addressed him as follows:—

Dr. Brammall,—

In awarding to you the Balance of the Proceeds of the Wollaston Fund, the Council has recognized with pleasure your careful and original investigations on the processes of metamorphism. You have also investigated the constitution and structure of the granites of Dartmoor, and thrown fresh light on the successive intrusions that have taken place, and the characters that distinguish them one from the other, as well as on the subsequent earth-movements to which they bear witness. The Council looks forward to a future as fruitful in contributions from you to Geological Science as the past has been.

The President then presented the Balance of the Proceeds of the Murchison Geological Fund to Dr. Arthur Elijah Trueman, addressing him as follows:—

Dr. Trueman,—

Palæontology, for its best expression, must not only be brought into relation with the problems of Neontology, but must itself lead the way towards solving those philosophical questions which the study of fossils is most likely to answer. Your published work shows that you have consistently kept in mind this aspect of Palæontology, whether in tracing the ontogeny or phylogeny

of Lias Ammonites, the sequence of Lamellibranchs in consecutive horizons of the Coal Measures, the relationships of Lias Gastropods, or the percentages of growth-shapes in *Gryphæa*. The same trend of mind has led you to the discussion of such different subjects as zonal nomenclature and the biological concept of species. Your investigations into Ammonite palæontology have enabled you not only to elucidate in great detail the Lias of Lincolnshire and Glamorgan, and to make a zonal map of the coast-line near Cardiff; but also to test in your practice the theories held by workers on the Lias in other districts. As a teacher, you have considered the advanced student by demonstrating new methods for studying the morphology of the Ammonite septum, and remembered the needs of the young amateur by giving him an elementary text-book. Further work by you on the Lias, especially work dealing with Ammonites and their evolution, is eagerly awaited.

In handing a moiety of the Balance of the Proceeds of the Lyell Geological Fund, awarded to Dr. James Allan Thomson, to Dr. J. S. Flett for transmission to the recipient, the President addressed him in the following words :—

Dr. Flett,—

I have much pleasure in handing to you a Moiety of the Balance of the Proceeds of the Lyell Fund awarded to Dr. James Allan Thomson, who has made important contributions to more than one department of Geological Science. His most extensive studies have been in the Palæontology of New Zealand, and in this connexion he has devoted his chief attention to the Brachiopods. He has also published valuable papers on petrological and economic subjects, especially in relation to New Zealand and Western Australia.

The President then handed the other moiety of the Balance of the Proceeds of the Lyell Geological Fund, awarded to Dr. William Alfred Richardson, to Mr. W. Campbell Smith for transmission to the recipient, addressing him as follows :—

Mr. Campbell Smith,—

Although Dr. Richardson is by profession a civil engineer, he has made substantial contributions to Geological Science, which constitute ample justification for the award to him of a Moiety of the Balance of the Proceeds of the Lyell Geological Fund. His work on the origin and mode of occurrence of concretionary rocks has gained wide recognition. Of still greater importance has been his examination of the relative frequency of occurrence of different types of igneous rocks, the results of which afford undeniable support to those who believe in a fundamental differentiation into basic and acid magmas, followed by a further segregation into different types.

The PRESIDENT then proceeded to deliver his Anniversary Address, dealing with the subject of regions of tension, evidenced by joints, slip-faults, and dykes. He enumerated the different causes of local tension, including torsion, but pointed out that, although the latter was found by Daubrée to give systems of fractures at right angles to one another, these might also be produced in any area with maximum and minimum directions of tension. He showed that Western Europe was largely characterized by tension towards the south-west, but that north-westward tension prevailed in North-Western Ireland and North-Western Scotland. The south-westward tension appeared to represent a slow drift towards the Atlantic 'deep' in the Bay of Biscay running north-westwards from Cap Breton, and the north-westward tension seemed to represent a drift towards the 'deep' trending north-eastwards between Rockall and Ireland. These 'deeps' themselves were to be attributed, not to 'foundering' but to a drift of the 'sial' masses of the Central Atlantic banks to the south-west and north-west respectively.

The nature and origin of the igneous rocks associated with tension were discussed. Other regions of tension were then described, especially that of Eastern Africa. Finally, the theories that have been advanced as to the cause of the drift of continental masses were considered.

The Ballot for the Council and Officers was taken, and the following were declared duly elected for the ensuing year:—

COUNCIL: Prof. Percy George Hamnall Boswell, O.B.E., D.Sc.; Prof. Arthur Hubert Cox, D.Sc., Ph.D.; Thomas Crook; Henry Dewey; James Archibald Douglas, M.A., D.Sc.; Gertrude Lilian Elles, M.B.E., D.Sc.; John William Evans, C.B.E., D.Sc., LL.B., F.R.S.; Prof. William George Fearnsides, M.A.; John Smith Flett, O.B.E., M.A., LL.D., D.Sc., M.B., F.R.S.; Prof. William Thomas Gordon, M.A., D.Sc., F.R.S.E.; Prof. Herbert Leader Hawkins, D.Sc.; Robert Stansfield Herries, M.A.; Sir Thomas Henry Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S.; William Dickson Lang, M.A., Sc.D.; Prof. John Edward Marr, M.A., Sc.D., F.R.S.; Horace Woollaston Monckton, Treas.L.S.; Tressilian Charles Nicholas, O.B.E., M.C., M.A.; Prof. Albert Charles Seward, Sc.D., F.R.S., F.L.S.; Walter Campbell Smith, M.C., M.A.; Leonard James Spencer, M.A., Sc.D.; Arthur Elijah Trueman, D.Sc.; Henry Woods, M.A., F.R.S.; and Sir Arthur Smith Woodward, LL.D., F.R.S., F.L.S.

OFFICERS:—*President*: John William Evans, C.B.E., D.Sc., LL.B., F.R.S.; *Vice-Presidents*: John Smith Flett, O.B.E., M.A., LL.D., D.Sc., M.B., F.R.S.; Sir Thomas Henry Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S.; Prof. Albert Charles Seward, Sc.D., F.R.S., F.L.S.; and Sir Arthur Smith Woodward, LL.D., F.R.S., F.L.S.; *Secretaries*: Walter Campbell Smith, M.C., M.A., and James Archibald Douglas, M.A., D.Sc.; *Foreign Secretary*: Prof.

John Edward Marr, M.A., Sc.D., F.R.S.; and *Treasurer*: Robert Stansfield Herries, M.A.

The thanks of the Fellows were unanimously voted to Prof. W. W. Watts, retiring from the office of Vice-President (and also from the Council), and to the other retiring Members of Council: Mr. F. N. Ashcroft, Dr. F. H. Hatch, Prof. S. H. Reynolds, and Sir Aubrey Strahan.

DANIEL-PIDGEON FUND.

On March 25th the Council propose to make an award of the sum now in their hands, amounting to £30 (or thereabouts), to a candidate of either sex, who must not be more than 28 or less than 21 years of age, and who is prepared to undertake some work of geological original research. The prescribed form of application can be obtained from the Permanent Secretary.

GLOYNE OUTDOOR GEOLOGICAL RESEARCH FUND.

The Council wish to call the attention of the Fellows to the above-mentioned Fund, the regulations concerning which are obtainable on application to the Permanent Secretary. The Fund is to be applied to the payment for actual work done in the field (excavations, etc.), but not to the reimbursement of personal expenses. The amount of income at present available is about £40.

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ABSTRACTS OF THE PROCEEDINGS

OF THE

GEOLOGICAL SOCIETY OF LONDON.

No. 1131.] March 5th, 1925. [Session 1924-25.

February 25th, 1925.

Dr. J. W. Evans, C.B.E., F.R.S., President, in the Chair.

B. Sahni, M.A., D.Sc., Professor of Botany in the University of Lucknow (India), was proposed as a Fellow of the Society.

Cecil Edward Redmill, B.Sc., 3 Manby Grove, Stratford, E. 15, was elected a Fellow of the Society.

The List of Donations to the Library was read; it included, among others, the following works:—Memoirs of the Geological Survey of Great Britain—'The Geology of the Country around Wem', by R. W. Pocock & D. A. Wray, with contributions by T. C. Cantrill, 1925; Philosophical Transactions of the Royal Society, B 406—'The Geology and Physical Geography of Chinese Tibet, & its Relations to the Mountain-System of South-Eastern Asia, from Observations made during the Percy Sladen Expedition, 1922', by J. W. Gregory & C. J. Gregory, 1925; Imperial Institute: Monographs on Mineral Resources—'Antimony-Ores', by E. Halse, 1925, and 'Bismuth-Ores', by R. Allen, 1925; 'Geology of the Republic of Haiti', by W. P. Woodring, J. S. Brown, & W. S. Burbank, 1924; 'Forme della Terra: Trattato di Geologia Morfologica (Geomorfologia), vol. ii, Tipi Regionali', by G. Rovereto, 1925; 'Life in a Sussex Windmill', 2nd ed., by E. A. Martin, 1921; 'The Natural History & Antiquities of Croydon', by the same author, 1923; Geographische Abhandlungen, ser. 2, pt. 2—'Die Morphologische Analyse; ein Kapitel der Physikalischen Geologie', by W. Penck, 1924; University of Oregon Publications, vol. ii, no. 7—'A Proposed Classification of Igneous Rocks', by E. T. Hodge, 1924; 'Inventaire des Périodiques Scientifiques des Bibliothèques de Paris', fasc. ii, 1924; and Jaarboek

van het Mijnwezen in Nederlandsch Oost-Indie, 1922—'Anthozoa uit het Perm van het Eiland Timor', by E. M. J. Koker; 'Die Nautiloideen der Mittleren & Oberen Trias von Timor', by A. Kieslinger; also 'Die Permischen Blastoiden von Timor', by J. Wanner, 1924.

The following communications were read:—

1. 'The Geology of Cader Idris (Merionethshire).' By Prof. Arthur Hubert Cox, D.Sc., Ph.D., F.G.S.

Cader Idris is an escarpment of Ordovician igneous rocks south of the Harlech Dome. An account of previous research is given. The strata have a general southward or south-eastward dip of about 40°, and the succession is as follows:—

			Thickness in feet.
Caradocian.	Talyllyn Mudstones	Grey-blue banded mudstones, with *Amplexograptus arctus* in the lowest beds	4000
Llandeilo.	Upper Acid Group	Rhyolitic and acid andesitic ashes and lavas	900–1500
	Llyn Cau Mudstones		500
	Upper Basic Group	Pillow-lavas (spilites), with tuff and chert-bands	400– 500
	Llyn-y-Gader Mudstones and Ashes	Grey-blue mudstones, with adinoles and massive ashes—*Glyptograptus teretiusculus*	450– 600
	Oolitic iron-ore		10– 20
	Lower Basic Group	Pillowy spilitic lavas, with many ash- and shale-bands	1500
Lower Llanvirn.	Cefn Hir Ashes	Massive agglomeratic ashes	500
	Bifidus Shales and Grits	*Didymograptus bifidus*, etc.	300– 600
Arenig.	Lower Acid Group	Rhyolite-lavas and ashes	500–1000
	Basement-Beds	Striped arenaceous flags and grits.....	150– 200
	Unconformity		
	Upper Cambrian.		

The volcanic rocks thus have a much greater time-range than had been proved hitherto. The four volcanic groups are separated one from the other by sediments of thicknesses so considerable that each represents a distinct episode.

Intrusive rocks are represented by numerous dolerite-sills, and by two great sills of granophyre, which are later than the dolerites. No basic intrusions occur above the highest basic extrusive rocks, and no acid intrusions above the highest acid extrusives. The granophyres seem to be related petrologically to the invaded rhyolites, and their intrusion is assigned to a pre-Bala or early Bala period.

The main structures have a north-east to south-west trend; but there is also a regular system of north-and-south minor folds that often cause a marked deflection of outcrops. This minor folding was operative in pre-Ordovician times, as shown by the relation of the Ordovician rocks to the Cambrian; also during Ordovician time, for the folds seem to have influenced sedimentation, and they controlled the emission and extension of the major intrusions, which originated in anticlines and terminated in synclines; the folds were further active in post-Silurian times.

Discussion.

Prof. W. G. Fearnsides congratulated the Author on his completion of the mapping of the Cader country, and on his presentation of the stratigraphical results. It is clear that the Arenig-Llandeilo volcanic rocks of Cader, even without the great granophyric and doleritic intrusions, must show a thicker, fuller, and petrographically more variable, succession of eruptions than in any other part of Wales. The proving of the lateral continuity across the Cader tract of the Lower Rhyolites and Lower and Upper Spilites and associated slate-bands, all intercalated within the apparently equivalent and complete rock-succession of Arenig Mountain (but not there represented), is important, and a valuable *caveat* against hasty generalizations concerning the age and succession of Ordovician volcanic rocks in other districts.

The finding of the *Glyptograptus-teretiusculus* fauna in mudstones closely associated with oolitic iron-ore suggests comparison with the pisolitic iron-ore deposits at Penmorfa and Tremadoc; but in that district no spilitic lavas have yet been discovered, either below or above the ore, and the needle-slates which adjoin the several ore-lenticles contain graptolites belonging to three or more distinct assemblages within the Llandeilo Series. At Tremadoc, in fact, the alignment of the old iron-workings follows one major and several minor thrust-planes, and the neighbouring well-characterized adinole-formation seems to be limited to the metamorphic aureoles of the later massive intrusions of gabbroid dolerite.

With regard to the apparently anomalous and variable behaviour of the granophyric and slaty rocks in the determination of topography, the speaker suggested that in Preglacial times most of the igneous rocks of North Wales, being comparatively susceptible to chemical attack, were at their outcrop much more profoundly weathered than the slates. Under glacial conditions unweathered slate was slowly abraded, but the decomposed igneous rock was rapidly and completely worn away. When the weathered material had disappeared the rate of denudation slackened considerably, and on the high ground erosion was mainly effective through the plucking-out of joint-blocks piece by piece, so that the rate of removal of material was determined rather by the disposition, frequency, and continuity of the joints, than by the intrinsic hardness of the rocks themselves.

Mr. A. K. Wells complimented the Author on the completion of the mapping of this highly important range. He referred to the marked and comparatively sudden changes in thickness of the various divisions of the Ordovician succession, and asked for information concerning the eastward thinning of the *Bifidus* Beds and the Lower Basic Group. He had no hesitation in correlating the volcanic rocks east of Rhobell with the Upper Basic and Upper Acid Groups of Cader Idris. He commented upon the probability of these groups lying entirely within the single zone of *Nemagraptus gracilis*, as the fauna of this zone occurs below the volcanic rocks in the Rhobell area and above them at Arenig Mountain.

The President asked, with reference to Prof. Fearnsides's remarks on the greater general erosion by 'plucking' of the granophyre than of the slates, whether the former was more extensively jointed than the latter. In Scandinavia the occurrence of jointing certainly appears to have been of primary importance in facilitating 'plucking'.

The Author, in reply, stated that he was fortunate in having the results of Prof. Fearnsides's researches on Arenig as a general guide to what might be expected on Cader Idris. Parts of the two sequences certainly presented considerable differences. He agreed that detailed examination of other areas would probably yield some unexpected results. The term 'Basement-Beds' had been used for a group of arenaceous strata that formed the local base of the Ordovician sedimentary rocks. This local base was probably some distance up in the Arenig zonal succession; but it was desired to avoid, so far as possible, the introduction of new stratigraphical place-names. He was quite satisfied that the oolitic iron-ore occurred at a constant stratigraphical horizon, and represented a definite sedimentary stratum. He was well aware of oolitic iron-ores at other horizons: as an example, he instanced the discovery by Mr. Wells of an oolitic band above the Lower Acid Group on Moel Offrwm, north of Dolgelley. It certainly appeared that there was little zonal difference between the fossils below and those above the upper volcanic rocks, and he considered that the 3000 to 4000 feet of mudstones and volcanic rocks from the Llyn-y-Gader Group upwards would all be represented in Pembrokeshire by a relatively small thickness of strata. He had devoted a good deal of attention to the petrology, but concluded that it was rather a matter for a separate paper.

2. 'The Dissection of Pitching Folds.' By Prof. Arthur Hubert Cox, D.Sc., Ph.D., F.G.S.

The dissection of a pitching fold may, under certain conditions, so affect outcrops that the true nature of the fold may be more or less completely obscured, so that in extreme cases an anticline may easily be misinterpreted as a syncline, and *vice versa*. In a pitching anticline cut along a plane inclined in the same direction

as the fold-axis, but at a smaller angle, the outcrops form a curve closing towards the pitch. If the inclination of the plane of dissection is fairly steep, as on a mountain-side, the effect is that the outcrop-curve sags downwards towards the centre of the fold-axis, giving a false impression of a syncline. An example of such a structure on Cader Idris is figured and described.

By altering the inclination of the plane of dissection across a pitching fold, outcrops can be made to take any desired curve, either concave or convex. In a pitching anticline the curves will have a downward convexity when the inclination of the dissecting plane is less than the angle of pitch, but an upward one when the direction of inclination of the dissecting plane is opposed to that of the pitch. There must, therefore, be some intermediate position in which the outcrop 'curve' is such that its projection on the map appears as a straight line, and the outcrop crosses the fold without apparent deflection.

A two-dimensional projection of a three-dimensional structure may be quite misleading. In some cases, the elevation, or the nearly vertical projection, like the view of a mountain-side, will be deceptive; in other cases, the geological map representing the horizontal projection will be deceptive. Such deceptive projections are liable to occur in districts of high relief, and may account for some of the difficulties experienced in tracing the continuity of folds across such areas.

Prof. Cox exhibited rock-specimens, microscope-sections, and lantern-slides in illustration of his paper on Cader Idris, and a model in illustration of his paper on pitching folds.

The next Meeting of the Society will be held on Wednesday, March 11th, 1925, at 5.30 P.M., when the following communications will be read:—

1. 'The Geology of the Llandovery District (Carmarthenshire)'. By Prof. O. T. Jones, M.A., D.Sc., F.G.S.
2. 'The Llandovery and Associated Rocks near Garth (Brecon-shire)'. By G. Andrew, M.Sc., F.G.S.
3. 'The Relations between the Llandovery Rocks of Llandovery and those of Garth'. By Prof. O. T. Jones, M.A., D.Sc., F.G.S., & G. Andrew, M.Sc., F.G.S.

Charles Weatheritt Scott, B.Sc., M.I.M.E., H.M. Junior Inspector of Mines, Leybourne House, Regent Street, Stoke-on-Trent, will be balloted for as a Fellow of the Society.

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ABSTRACTS OF THE PROCEEDINGS

OF THE

GEOLOGICAL SOCIETY OF LONDON.

No. 1133.] **April 3rd, 1925.** [Session 1924–25.

March 25th, 1925.

Dr. J. W. Evans, C.B.E., F.R.S., President, in the Chair.

Geoffrey Chambers Flower, 42 Nevern Square, S.W. 5, and Noel Ewart Odell, A.R.S.M., 44 Compayne Gardens, South Hampstead, N.W. 6, were proposed as Fellows of the Society.

B. Sahni, M.A., D.Sc., Professor of Botany in the University of Lucknow (India), was elected a Fellow of the Society.

The List of Donations to the Library was read; it included, among others, the following works:—'Radioactivity & the Surface History of the Earth', by J. Joly, 1924; 'Introductory Geology', by L. V. Pirsson & Charles Schuchert, 1924; 'The Evolution of Climate', 2nd ed., by C. E. P. Brooks, 1925; 'The Temperatures of Hot Springs & the Sources of their Heat and Water-Supply', by various authors, 1924; Geological Survey of Uganda, Memoir No. I—'Petroleum in Uganda', by E. J. Wayland, 1925; 'Report on Petroleum Prospects in the Kimberley District of Western Australia & the Northern Territory', by A. Wade, 1924; 'Explanatory Note & Contour-Map of the Trencherbone Seam of the Lancashire Coalfield', by G. Hickling, 1924; 'Catalogue des Invertébrés Fossiles de l'Egypte, représentés dans les Collections du Musée de Géologie au Caire: Terrains Jurassiques—1ère Partie: Echinodermes', by R. Fourtau, 1924; 'Révision des Scaphopodes, Gasteropodes & Céphalopodes du Montien de Belgique: 2ème Partie', by M. Cossmann, 1924; 'Geological Survey of Grenada & the (Grenada) Grenadines', by K. W. Earle, 1924; and 'Contributions à l'Etude des Roches Eruptives Indochinoises', by R. Bourret, 1924.

The following communications were read:—

1. 'On the Clay Pebble-Bed of Ancon (Ecuador)'. By Charles Barrington Brown, M.C., M.A., F.G.S., and Robert Ashley Baldry, B.A., F.G.S. (Read by Dr. J. A. Douglas, M.A., Sec.G.S.)

This paper gives an account of a peculiar clay pebble-bed, varying in thickness from 550 to 900 feet, which crops out on the southern shore of the Santa Elena Peninsula, at the northern extremity of the Gulf of Guayaquil (Ecuador). It consists of polished, rounded, or subrounded pebbles of harder clay, embedded in a matrix of softer clay; the pebbles vary from the size of a pin's-head up to 2 or 3 inches in diameter. In addition, it contains large and partly rounded boulders of sandstone, foraminiferal limestone, grit, polished quartz-pebbles, etc., and in some cases masses of limestone occur many cubic yards in bulk. The upper limit of the bed is usually well-defined, and has subsequently been faulted and folded with the overlying strata. The lower limit is never seen in the sea-cliffs, but has been proved by boring. It is considered by the Authors to be the result of a great post-Oligocene overthrust in soft sands and clays of Tertiary age. The direction of thrusting is from the east-south-east (the Brazilian over the Pacific block). The occurrence is thought to give an insight into the mechanism of overthrusting in soft strata, and to illustrate the formation, by this means, of a thick stratum difficult to differentiate from a stratigraphical unit or a boulder-clay.

Discussion.

Mr. G. W. Lamplugh said that the brief description and diagrams of the Ecuadorian 'Pebble-Bed' seemed to show that it possessed many features in common with the crush-conglomerates of the Isle of Man, and, while of greater thickness, behaved similarly in its relationship to the bordering rocks. The Manx rocks were indurated before their brecciation, and it would be most interesting if the Ecuadorian bed proved to be an example of similar disintegration of soft rocks. A distinctive character of the crush-conglomerates known to the speaker was that their fragmental material was derived wholly from the associated strata. In the present case, it had not been made clear whether the limestone-masses of the conglomerate had their counterpart in the bordering stratified sequence. The paper would undoubtedly lead to further investigation and discussion.

Prof. V. C. Illing said that it was difficult to discuss the remarkable conclusions of the Authors in their absence; but their description of the pebble-bed reminded the speaker of similar examples in Trinidad, where there was a zone of pebble-beds following a zone of thrusting. In this case, however, the pebbles were the result of shoal conditions produced penecontemporaneously with the thrusting, and not formed by the thrusts themselves.

Such an origin might explain the peculiar conditions described in the paper more reasonably than the theory presented by the Authors.

Dr. J. A. Douglas agreed that it was hardly fair to criticize the paper in the absence of the Authors, but thought that no evidence had been adduced to show how the actual pebbles of clay had been formed.

He found it very hard to understand how two generations of rounded pebbles, one inside the other, could be formed in a plastic rock like a clay, by a movement that had caused fracture and shearing of the hard pebbles in the associated conglomerate. Further, in dealing with an exposure of so limited an extent situated 130 miles west of the Andes, he considered that the suggestion of a thrusting of the Brazilian block over the Pacific block was entirely unjustified.

Prof. W. W. Watts said that he was not convinced by the evidence brought forward that the conglomerates were produced by crushing. The structures exhibited in the diagrams were not very like those seen in, for instance, the crush-conglomerate of the Isle of Man, and he thought that the paper needed fortifying with photographs of exposures and with microscopic evidence. He pointed out the frequent association of breccias with orographic movement, and instanced the case of the Permian Breccias of Britain. He also referred to the occurrence of heavy screes and landslips, as in the Upper Rhine Valley at Flims and elsewhere, where their occurrence was associated with the outcrop of the upper ends of thrust-planes which gave rise to steepened slopes and the activity of all gravitational agencies of denudation.

Dr. T. O. Bosworth and Prof. O. T. Jones also spoke.

2. 'The Pre-Cambrian Volcanic Rocks of the Malvern Inlier'. By John Isaac Platt, M.Sc., F.G.S.

The region described occurs about the central part of the Malvern Range, and consists largely of volcanic rocks. Although the area has received considerable attention at the hands of earlier investigators, the volcanic rocks have not been described of recent years. These rocks are of Pre-Cambrian age, and belong to a distinctly sodic suite comprising soda-rhyolites, keratophyres, and spilites.

The rhyolites possess a ground-mass which shows a micrographic structure, and represents the eutectic mixture of the constituent minerals: namely, quartz and felspar (chiefly albite). In many of the types phenocrysts of these two minerals occur. The rhyolites, as well as the majority of the other rocks, contain epidote in varying amounts. Chlorite sometimes occurs with the epidote, and the association of these two minerals suggests simultaneous formation, while further there is evidence of a change of some of the chlorite into epidote.

The keratophyres contain lath-shaped albite-crystals and much magnetite, and show trachytic structure. Mafic minerals are

markedly absent, but chlorite and epidote are well represented. There are several interesting variations of this type.

The more basic lavas, the spilites, are usually vesicular. No pillow-structure was seen. Here again soda-rich felspars occur, but they are frequently in the form of microlites, which are so arranged as to give a variolitic structure to the rock. Secondary chlorite and epidote are also present.

There are a few pyroclastic rocks developed. Although those examined were of an acid composition, there can be little doubt that more basic types also occur.

A number of minor intrusions have been injected into the lavas. In the south-west of the area described two dykes of a comparatively fresh ophitic dolerite crop out, while a subophitic variety of the same type is found in the north-west. There are several dykes and a volcanic neck of epidiorite in the east of the area. This epidiorite appears to be an uralitized modification of the coarse ophitic dolerite. In some varieties of this rock the secondary changes have been so great as to produce an epidote-uralite-rock.

As the boundaries of the series are all faulted ones, the Pre-Cambrian age can only be determined by indirect means.

Discussion.

Prof. V. C. Illing congratulated the Author on his method of presenting the paper, but could not agree with his field evidence. The results of the speaker's work differed materially from the Author's, with regard both to boundaries and to interpretations. The speaker gave his interpretation of the field data, and set forth evidence to show that the Malvernian rocks were definitely older than the volcanic series, also that the gneisses suggested an old land-surface, chemically weathered under the volcanic rocks in one rock.

Prof. O. T. Jones also spoke.

The Author thanked the Fellows present for their reception of the paper, and especially Prof. Illing for his kindly criticism. He regretted his ignorance of the fact that Prof. Illing was also at work on the area, and considered it unfortunate that no earlier communication had been established between them. In so difficult a piece of country the combined work of two investigators was more likely to lead to a true elucidation of the structure than the individual work of either.

The Author had not resorted to the use of the shovel, and in consequence was not in a position to criticize the evidence revealed in the trenches dug by Prof. Illing. The Author stated that he had found rhyolites west of the Waterworks Cottage, and also on Tinker's Hill, but had failed to locate any east of Foxhall Farm. He was not satisfied that the interpretation given by Prof. Illing of the relation of the rhyolites to the keratophyres between Broad Down and Hangman's Hill was the correct one.

He was pleased to know that the presence of Warren House rocks beneath the detrital matter in the south had been definitely established, and suggested that both Prof. Illing and himself should, in the near future, visit and examine the area together.

Diagrams were exhibited in illustration of the paper by Mr. C. Barrington Brown & Mr. R. A. Baldry, and rock-specimens and lantern-slides were exhibited in illustration of Mr. Platt's paper.

The next Meeting of the Society will be held on Wednesday, April 22nd, 1925, at 5.30 P.M., when the following communication will be read:—

'The Stratigraphy of the Laki Series (Lower Eocene) of parts of Sind and Baluchistan (India); with a Description of the Larger Foraminifera contained in those Beds'. By W. L. F. Nuttall, D.F.C., B.A., F.G.S.

At the Meeting on May 6th, Mr. E. B. Bailey, M.C., B.A., F.R.S.E., F.G.S., will deliver a lecture on 'The Tertiary Igneous Geology of the Island of Mull'.

The Society's Apartments will be closed, on account of the Easter Holidays, from the evening of Thursday, April 9th, until the morning of Wednesday, April 15th, 1925.

No. 321 of the Society's Quarterly Journal, Part 1 of Vol. LXXXI for 1925, now in course of issue, contains the following papers:—

1. The late R. W. Hooley on the Skeleton of *Iguanodon atherfieldensis* sp. nov.
2. Dr. K. S. Sandford on the Fossil Elephants of the Upper Thames Basin.
3. Prof. H. H. Swinnerton on *Woodthorpea wilsoni* gen. et sp. nov.
4. Dr. C. E. Tilley on Metamorphic Zones in the Southern Highlands of Scotland.

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ABSTRACTS OF THE PROCEEDINGS

OF THE

GEOLOGICAL SOCIETY OF LONDON.

No. 1134.] **April 30th, 1925.** [Session 1924-25.

April 22nd, 1925.

Dr. J. W. Evans, C.B.E., F.R.S., President, in the Chair.

Satyabodna Balkrishna Hudlikar, M.A., State Geologist, The Residency, Indore (Central India); and John John Thomas, Mining Engineer, Hawthorn Villa, Kendal, were proposed as Fellows of the Society.

The List of Donations to the Library was read; it included, among others, the following works:—Imperial Institute Monographs: 'Bauxite & Aluminium', by W. G. Rumbold, 1925; 'Fossil Zones in the Carboniferous Rocks', by O. T. Jones, 1924; 'Lead- & Zinc-Ores in the Slaty Rocks of Britain', by the same author, 1924; and 'On the Labradorization of the Feldspars', by O. B. Böggild, 1924.

The following communication was read:—

'The Stratigraphy and Palæontology of the Laki Series (Lower Eocene) of Parts of Sind and Baluchistan (India)'. By Winfred Laurence Falkiner Nuttall, D.F.C., M.A., F.G.S.

In the original geological survey by W. T. Blanford the massive white foraminiferal Eocene limestones of Sind were all grouped in the Kirthar Series. It was not until later that F. Nœtling and E. W. Vredenburg recognized that some of the limestones, with a thickness of about 600 feet, found along the Laki Range and in Lower Sind contained a different and earlier fauna of Foraminifera than that of the Kirthar Series as exposed in the Kirthar Range. Vredenburg, employing for these beds the term Laki Series,

divided them into two groups: the *Alveolina* Limestone and the Meting Shales. Owing to complications in the geological structure, he failed to recognize the complete geological succession near Meting in Lower Sind.

In the area near Meting the Author proposes the following divisions in the Laki Series:—Laki Limestone, Meting Shales, Meting Limestone, Basal Laki Laterite. The term *Alveolina* Limestone is discarded, as *Alveolinæ* are found in both the Laki and the Meting Limestones. The Meting Limestone is correlated with the Dunghan Limestone of R. D. Oldham, which is found in the Bolan Pass and other places in Baluchistan. The Ghazij Shales of Baluchistan, which are absent in Sind, pass up conformably into the Lower Kirthar Series. The upper part of these shales is younger than the Laki Limestone. In Sind the Laki Limestone is overlain unconformably by the Middle Kirthar, Nari (Oligocene), or Lower Manchar (Pliocene) beds. The Laki Series rests unconformably on the Upper Ranikot, with the upper members of the Laki Series as traced northwards overlapping the lower.

The *Nummulites* and *Assilina* from India have not been described since the classical work of D'Archiac & Haime in 1853, when the specimens were not separated according to their stratigraphical horizons. The following larger foraminifera, which are found associated in Thanetian and Cuisian beds of Southern France and the Pyrenees, are common in the Laki Series of Sind and Baluchistan:—*Nummulites atacicus*, *N. irregularis*, *Assilina granulosa*, *Alveolina oblonga*, *A. subpyrenaica*, *Flosculina globosa*, and *Orbitolites complanata*. On the basis of the occurrence of this fauna, which is different from that of the Kirthar Series, the Author considers the Laki Series to be of Lower Eocene age rather than Lower Lutetian, as has hitherto been supposed.

He expresses his thanks to the directors of the Whitehall Petroleum Corporation for permitting the publication of some of the results of a geological reconnaissance undertaken by him on their behalf.

Discussion.

Dr. A. M. Davies expressed his sense of the value of the paper, but suggested caution as to the transference of the Laki from Middle to Lower Eocene, several of the foraminifera quoted being characteristic Lutetian species. He also suggested that the excessive thickening of the test in *Flosculina* (repeated in the Miocene *Flosculinella*) might be a phylogerontic feature, rather than an effect of environment, seeing that normal forms of *Alveolina* were found in the same rock with the thickened *Flosculina*.

Mr. R. D. Oldham also spoke.

The Author, in reply to Dr. Davies, said that he had observed another species of *Alveolina* in which the thickening of the shell-wall was variable, the foraminifer thereby exhibiting transitional stages from a characteristic Alveoline to a typical Flosculine.

This species is *A. elliptica* Sowerby, which occurs in the Kirthar Series of Baluchistan, Cutch, and Assam. The type of *A. elliptica* with no thickening of the shell-wall is found in all three localities, and the varieties showing Flosculine tendencies only in Cutch. In this instance the Flosculine variety has a more limited geographical distribution in India than the type of the Alveoline.

With regard to the exact age of the Laki Series, more light would be thrown on this by an examination of the foraminifera of the underlying Ranikot Series and the overlying Kirthar Series. The Author was studying faunas from these horizons, and hoped at a later date to be able to publish his results.

He further mentioned that, during his geological reconnaissance of Sind, he had found Dr. W. T. Blanford's memoir of great assistance. As regards the conglomeratic Dunghan Limestone of Baluchistan, in some localities he had noticed it to contain angular fragments, which fact brought evidence against the supposition that this formation was of concretionary origin.

The Author agreed that there appeared to be a palæontological break between the Dunghan Limestone and the Ghazij Shales. He considered that the difference in fauna between the two formations was rather one due to facies than due to age. The Dunghan Limestone with abundant *Alveolinæ* was deposited in relatively shallow water, and the Ghazij Shales containing chiefly *Nummulites* and *Assilinæ* were of deeper-water origin.

In reply to the Discussion on his and Mr. C. Barrington Brown's paper, 'On the Clay Pebble-Bed of Ancon (Ecuador)', read on March 25th (see Abstract 1133, pp. 62–63), Mr. R. A. Baldry made the following remarks :—

The chief criticism levelled against the paper was that it did not bring forward convincing evidence to prove that the clay pebble-bed was formed by thrusting. He repeated the arguments put forward in the paper, amplifying them and supporting them by several lantern-slides.

First, he objected to the use of the word conglomerate in describing the bed. The word is associated so often with pebbles in a sandy matrix, that it might give a wrong impression of a formation which is more than nine-tenths clay.

He recapitulated the evidence for its formation by thrusting :

(1) The absolute lack of stratification, and the large size of the boulders in a clay-matrix, precludes the possibility of ordinary sedimentary accumulation. Some boulders weigh several tons.
(2) The slickensiding polish on all the clay-pebbles and the high polish on the isolated quartz-pebbles indicate differential movement within the bed.
(3) The upper limit transgresses the bedding-planes of the superincumbent strata.
(4) The upper limit is always a thrust-plane, from which minor thrusts branch into the upper block.

(5) The most convincing evidence of all is the presence of a transitional stage where tearing-away of the sole of the upper block is visible, and one sees a cinematographic picture, so to speak, of the process of formation.
(6) No other hypothesis accounts for the large included blocks of stratified material; these may be 100 feet thick, and possibly several hundred feet long. The portions of these that are visible have the typical eye-shape that one associates with shearing movement.

The great thickness of the bed, compared with that of other known crush-conglomerates, is due to its formation from very soft strata. At Lobitos, in Northern Peru, belts of extreme brecciation are associated with normal faults. An instance is known of a fault with a throw of 2000 feet, in which the breccia-zone is only a few feet wide where both sides are of hard strata; and yet, a short distance away, where the fault passes through clays, the belt is 100 yards across.

In reply to Mr. Lamplugh, he said that the material composing the bed is exactly similar to that of the sole of the overlying block. The included lenticles of stratified material, too, are identical with the rocks above. The foraminifera in the bed are like those of the sandstones in the stratified series. Where a sandstone-seam or a pebble-bed forms the sole of the upper block, one can see where portions have been pulled off it, and included in the clay-matrix. The limestone, however, has not yet been found in the stratified series. It is only a thin bed, and might easily be faulted out in the cliff-section, and obscured by the Quaternary deposits inland. The foraminifera are like those of the sandstones above.

With regard to Prof. Illing's examples in Trinidad, the Ancon pebble-bed is confined to the zone of thrusting, and nowhere extends above it. There is no evidence of shoal conditions, except much higher in the succession.

In reply to Dr. Douglas, Mr. Baldry said that the shearing of the pebbles occurred when the pebbly sandstones forming the base of the thrust-plane were breaking up. If the movement is reasonably slow, the maximum stress is limited by the rigidity of the matrix, and even a hard clay-pebble is protected, once it is surrounded by a cushion of softer clay.

The expression 'Brazilian block over the Pacific block' was meant to be directional only. It would have been clearer to have written 'from land to sea, or from the direction of the Brazilian block over the Pacific'. The impression of a hard resistant block on the south-east is derived from several years' investigations in Northern Peru and Ecuador, and not alone from the area described in the paper.

In reply to Prof. Watts, Mr. Baldry opined that the difference in structure from the typical crush-conglomerates can be accounted for by the difference in the raw material. Photography is difficult, owing to the lack of contrast in the materials that form the bed, and it did not seem that the microscope could be of much use in this matter. Before the speaker went to Ecuador, he had suggested

a possible mode of formation by submarine landslip near a large geofault at the edge of the continental shelf. This theory died a natural death, so soon as he saw the actual field-evidence, and the present theory took its place.

'Post-Oligocene' in the abstract (p. 62) should read 'Post-Eocene'.

Lantern-slides were exhibited in illustration of Mr. W. L. F. Nuttall's paper, and of Mr. R. A. Baldry's remarks.

A quartzite-pebble (supposed to be a dreikanter), from a coal-seam at Ashby-de-la-Zouch, was exhibited by Mr. H. G. Mantle, F.G.S.

The next Meeting of the Society will be held on Wednesday, May 6th, 1925, at 5.30 P.M., when a Lecture will be delivered by Mr. E. B. Bailey, M.C., B.A., F.R.S.E., F.G.S. on 'The Tertiary Igneous Geology of the Island of Mull'.

Geoffrey Chambers Flower, 42 Nevern Square, S.W. 5, and Noel Ewart Odell, A.R.S.M., 44 Compayne Gardens, South Hampstead, N.W. 6, will be balloted for as Fellows of the Society.

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ABSTRACTS OF THE PROCEEDINGS

OF THE

GEOLOGICAL SOCIETY OF LONDON.

No. 1135.] May 15th, 1925. [Session 1924-25.

May 6th, 1925.

Dr. J. W. Evans, C.B.E., F.R.S., President, in the Chair.

Geoffrey Chambers Flower, 42 Nevern Square, S.W. 5, and Noel Ewart Odell, A.R.S.M., 44 Compayne Gardens, South Hampstead, N.W. 6, were elected Fellows of the Society.

The List of Donations to the Library was read; it included, among others, the following works:—'First Report on the Geology & Mineral Resources of British Somaliland', by R. A. Farquharson, 1924; 'Bau & Bildung der Erde', by J. Walther, 1925; United States Geological Survey Bulletin—No. 761, 'Molybdenum-Deposits: a Short Review', by F. L. Hess, 1924; and No. 769, 'The Geologic Time Classification of the United States Geological Survey compared with other Classifications, accompanied by the Original Definitions of Era, Period, & Epoch Terms', compiled by M. G. Wilmarth, 1925; Memoirs of the Geological Survey of India, vol. xlviii, pt. 2—'The Geology of Parts of the Persian Provinces of Fars, Kirman, & Laristan', by G. E. Pilgrim, 1924; Palæontologia Indica, n. s. vol. vi, No. 4—'Upper Carboniferous Fossils from Chitral & the Pamirs', by F. R. C. Reed, 1925; and n. s. vol. viii, No. 2—'The Anthracotheriidæ of the Dera Bugti Deposits in Baluchistan', by C. F. Cooper, 1924; 'On the Fossil Flora of the Bristol & Somerset Coalfield', by R. Crookall, 1925; Studien über die Eisscheide in Zentralskandinavien', by G. Frödin, 1925; 'Stratigraphy of China, pt. i—Palæozoic & Older', by A. W. Grabau, 1924; Palæontologia Sinica, ser. B, vol. i, pt. 4—'Contributions to the Cambrian Faunas of North China', by Y. C. Sun, 1924; and ser. C, vol. i, pt. 1—'Tertiary Vertebrates from Mongolia',

by M. Schlosser, 1924; pt. 2—'Fossil Primates from China', by M. Schlosser, 1924; Geological Survey of Nigeria, Occasional Paper No. 1—'Brown Coal in Nigeria', by R. C. Wilson, 1925; 'Die Erdbeben des Œstlichen Teiles der Ostalpen, ihre Beziehungen zur Tektonik & zu den Schwereanomalien', by F. Kautsky, 1924; and 'Edad de los Fósiles Peruanos & Distribución de sus Depositos', by C. I. Lisson & B. Boit, 1924.

Mr. Edward Battersby Bailey, M.C., B.A., F.R.S.E., F.G.S., then proceeded to deliver a lecture on the Tertiary Igneous Geology of the Island of Mull, illustrated by lantern-slides.

He asked his hearers to remember that he was only one of a small group of workers who had recently been employed in adding to our knowledge of the geology of Mull. In the Geological Survey Memoir (1924), the share of each participant is indicated by initials.

The columnar lavas of Staffa and South-Western Mull were described, with especial reference to Scrope's double-tier jointing, Iddings's explanation of the apparent repugnance of approaching columns, and Macculloch's tree that stands upright although submerged in lava.

Attention was then focussed upon Judd's region of central pneumatolysis (propylitization), where, within an area measuring 15 miles in diameter, it is impossible to find a lava that has retained its olivine undecomposed.

Judd's conception of central subsidence was next discussed. It now appears, from the disposition of lava-types and other considerations, that central subsidence culminates in two adjacent calderas. The occurrence of many pillow-lavas within one of these calderas—at the centre of a manifestly terrestrial volcano—points to the frequent presence of a crater-lake. The crater-hollow must have been renewed by intermittent subsidence—for instance, Kilauea and Askja. The rim-craters of Askja may be taken as a surface-manifestation of a ring-dyke. Ring-dykes are numerous in Mull, where their most perfect example is the Loch Ba felsite, traced by Mr. W. B. Wright and Mr. J. E. Richey. Ring-dykes are known at other British Tertiary centres, and also at Glen Coe and Ben Nevis. Many ring-structures occur in Iceland, in addition to the Askja caldera, and have been described by Thoroddsen. At Oslo they appear in Brögger & Scheteliq's map (1923).

There is conspicuous folding in Mull attributable to the lateral expansion of an early ring-dyke. Similar folding does not recur in connexion with later ring-dykes. These may, in some cases, have made room for themselves by stoping en masse, and in others by pushing country-rock inwards towards a central orifice.

Several ring-dykes in Mull show gravitational differentiation, and the lecturer explained that he had been convinced by Dr. H. H. Thomas and Mr. A. F. Hallimond that this had taken place during crystallization.

Cone-sheets were passed in review, and emphasis laid on th great aggregate bulk.

Finally, the Mull swarm of north-westerly dykes was considered The dyke-swarm owes its location to the previous development of the central conduit. One of its members, with ash-vents distributed along its course, has furnished Dr. B. N. Peach and others with a convincing analogue of the Laki fissure in Iceland. Probably, many of the Mull dykes fed fissure-eruptions, as Sir Archibald Geikie long ago maintained; but the products of most, if not all, of these eruptions have been eroded away.

The next Meeting of the Society will be held on Wednesday, May 20th, 1925, at 5.30 P.M., when the following communication will be read:—

'The Liassic Rocks of the Radstock District (Somerset).' By J. W. Tutcher & Dr. A. E. Trueman, F.G.S.

Mr. Henry Dewey, F.G.S., will exhibit Palæolithic implements of Chellean type found in the gravel of Hyde Park, London.

Satyabodha Balkrishna Hudlikar, M.A., State Geologist, The Residency, Indore (Central India); and John John Thomas, Mining Engineer, Hawthorn Villa, Kendal, will be balloted for as Fellows of the Society.

The volume embodying the Report of the Discussion on the Physical Chemistry of Igneous Rock-Formation, at the joint meeting of the Faraday Society, the Geological Society, and the Mineralogical Society, held on October 22nd, 1924, will shortly be available. The published price is 6*s*. 6*d*., but the price to Fellows of the Geological Society will be 4*s*. 6*d*. Fellows desiring copies should communicate directly with the publishers, Gurney & Jackson, 33 Paternoster Row, E.C. 4, enclosing a remittance in payment of the copies required, and stating that they are Fellows of this Society.

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ABSTRACTS OF THE PROCEEDINGS

OF THE

GEOLOGICAL SOCIETY OF LONDON

No. 1136.] June 2nd, 1925. [Session 1924–25.

May 20th, 1925.

Dr. J. W. Evans, C.B.E., F.R.S., President, in the Chair.

Albert George Brighton, B.A., Christ's College, Cambridge; Percy Harrison, F.S.I., Borough Engineer & Surveyor, High Barn, Alkrington, Middleton (Lancashire); and Joseph Slomnicki, A.R.S.M., Geologist, c/o Steaua Romana, Campina (Rumania) were proposed as Fellows of the Society.

Prof. William Morris Davis, Library Museum, Cambridge (Massachusetts); and Dr. Gerhard Holm, Geological Survey of Sweden, Stockholm, were proposed as Foreign Members of the Society.

Prof. Paul Lemoine, Paris; Dr. Victor Madsen, Copenhagen; Prof. Paul Niggli, Zürich (Switzerland); Prof. Josef Felix Pompeckj, Berlin; Dr. T. Wayland Vaughan, Washington (D.C.), U.S.A.; and Dr. Mikhail Dimitrivich Zalessky, Petrograd, were proposed as Foreign Correspondents.

John John Thomas, Hawthorn Villa, Kendal (Westmorland), was elected a Fellow of the Society.

The List of Donations to the Library was read; it included, among others, the following works:—Memoirs of the Geological Survey of England & Wales—'The Geology of North London', by C. E. N. Bromehead, with contributions by H. G. Dines & J. Pringle, 1925; 'Block Diagrams & other Graphic Methods used in Geology & Geography', by A. K. Lobeck, 1924; 'Chart showing the Chemical Relationships in the Mineral Kingdom', by P. C. Putnam, 1925; Proceedings of the Empire Mining & Metallurgical Congress held in London, June 3rd–6th, 1924, in five volumes, 1925; Monographs of the Palæontographical Society, vol. lxxvi: 'The Macrurous Crustacea', part 1, by Henry Woods; 'The Gault Ammonites', part 2, by L. F. Spath; 'The Pliocene Mollusca', vol. ii, part 4, by F. W. Harmer; and 'The Palæozoic

Asterozoa', part 6, by W. K. Spencer, 1925; United States Geological Survey, Professional Paper No. 135: 'The Composition of the River and Lake Waters of the United States', by F. W. Clarke, 1924; Philosophical Transactions of the Royal Society, ser. B, No. 407—'The Caytoniales, a new Group of Angiospermous Plants from the Jurassic Rocks of Yorkshire', by H. Hamshaw Thomas, 1925; Bulletin of the Geological Survey of Canada, No. 39—'Colour-Printing of Geological Maps', by C. O. Senécal, 1925; 'Die Kriegsschauplätze 1914–1918 geologisch dargestellt', Heft 1—'Elsass', by E. Kraus & W. Wagner, 1924; Heft 4—'Vor Verdun', by F. Sturm, 1923; Heft 5—'Argonnen & Champagne', by K. Hummel, 1923; and Heft 12—'Geologie der Zentralen Balkanhalbinsel', by F. Kossmat, 1924; 'Erz- & Mineral-lagerstätten des Thüringer Waldes', by B. von Freyburg, 1923 (the foregoing five items were presented by Dr. R. H. Rastall); Mémoires du Service Géologique de l'Indochine, vol. xi, pt. 1: 'Nouvelle Contribution à l'Étude des Fusulinidés de l'Extrême-Orient', by Mlle. M. Colani, 1924; 'Die Eisenerz- & Kohlen-vorräte des Ungarischen Reiches: I. Teil—'Die Eisenerze', by K. von Papp, 1919; 'Structure & Ecology of Samoan Reefs', 'Causes which Produce Stable Conditions in the Depth of the Floors of Pacific Fringing Reef-Flats', 'Inability of Steam-water to Dissolve Submarine Limestones', 'Growth-rate of Samoan Corals', and 'Rose Atoll, American Samoa': all by A. G. Mayor; 'Bergens Museum, 1925: En Historisk Fremstilling'; 'Studier over Isrand-Terrassene Syd for de Store Œstlandiske Sjöer', by O. Holtedahl, 1924; 'Minéralogie des Volcans, ou Description de toutes les Substances Produites ou Rejetées par les Feux Souterrains', by M. Faujas de Saint-Fond, 1784 (presented by Dr. A. Harker); and 'Brief Remarks on the Geology of Derbyshire, with the History of the Fluor Spar', by W. Adam, 1846 (presented by Mr. D. A. MacAlister).

On behalf of Mr. Henry Dewey, F.G.S., Palæolithic implements of Chellean type found in the gravel of Hyde Park, London, were exhibited, and the following observations sent by him were read by the President:—

'The implements on the table were all collected by me from gravel thrown out of a deep trench in Hyde Park. The trench has been dug in order to repair an old disused sewer, and has proved a thickness of upwards of 26 feet of gravel and sand. The dimensions of the pit are: length = 44 feet; breadth = 14 feet; depth = 40 feet. The London Clay has been exposed at the northern end of the excavation, but falls suddenly at the southern end to an unknown depth. The gravel, therefore, covers a step-like fracture, which curves round from west-and-east to north-east. The stones are principally Chalk-flints; but perhaps 2 per cent. are quartzite-pebbles from the Bunter pebble-beds and white vein-quartz. One of the quartzite-pebbles measured 10 inches in length; on a smooth side deep striæ scoured the stone. They resembled true glacial striæ.

'The implements were all taken from material that had been removed from a depth of 26 feet. They include one hand-axe of Chellean type; the topmost portion of a second hand-axe; two choppers worked along the edges so as to provide a comfortable hold; two long flakes or flake-scrapers; a

broad flake or grattoir; and some pieces showing a certain amount of human workmanship. The height of the top of the London Clay at this locality is approximately 63 feet above O.D. The surface of the gravel is at 89 feet.

'The finds may be compared with others in similar spreads of gravel near by. Four implements were discovered in the gravel when the foundations of the Piccadilly Hotel were dug. They are now in the London Museum. All four are very fine examples of Palæolithic flint-work. They are hand-axes with sharp straight edges, and no sign of zigzag work is seen on them. They measure about 5 inches in length, and are flaked all over.

'In the gravel underlying the Regent Palace Hotel three similar Palæolithic implements were found. Two are not quite whole: these also are in the London Museum. They are in a condition similar to that of the Piccadilly finds, and are obviously of the same age. The gravel in which they were found lies on the London Clay.

'In Eagle Place, Jermyn-street, and adjacent to the Museum of Practical Geology, two hand-axes have been dug out from the gravel. They are of much less finished workmanship.'

The following communication was read:—

'The Liassic Rocks of the Radstock District (Somerset)'. By John William Tutcher and Arthur Elijah Trueman, D.Sc., F.G.S.

The Liassic rocks described are those found within a radius of about 4 miles from Radstock. These rocks are unusually interesting, because in some divisions they are very thin; the total thickness of Lias does not exceed 200 feet, and is often much less. The succession may be summarized as follows:—

		Feet.
Upper Lias:	Sands, marl, and ironshot limestone, up to...	9
Middle Lias:	Unknown, probably always absent.	
Lower Lias:	*Striatum* and *Capricornum* Clays, up to ..	120
	Jamesoni Limestone, up to...	10
	Armatum Bed, with derived Echiocerates...	0 to 1½
	Raricostatum Clay	0 to 1½
	Obtusum Nodules	¼ to 2½
	Turneri Clay.....	0 to 5
	Bucklandi Bed (*Euagassiceras*, etc.)	0 to 1
	Angulata and *Planorbis* Zones	2 to 30
	White Lias, with Sun-Bed	20

The peculiarities of the Lias of this district are known to be related to its position immediately north of the Mendip Axis, along which movement took place intermittently during the early Mesozoic Era. Notwithstanding the numerous non-sequences within the Radstock Lias, an unusual number of ammonite faunas are richly represented, often in remanié deposits.

Studies of the succession in many exposures have made it possible to elucidate in some detail the nature of the movements that took place during the deposition of the Lower Lias. These conclusions may be summarized as follows:—

(1) Deposition of White Lias during a time of fairly uniform subsidence; similar conditions during the deposition of the *Planorbis* and *Angulata* Zones, but less uniform.

(2) Period of folding along east-and-west axes, and denudation of the anticlinal areas.

(3) Deposition renewed during the hemera of *Sauzeani* (*Bucklandi* Bed). Deposition continued intermittently during the formation of the *Turneri* Clay.
(4) Uplift in the south, followed by denudation of much of the clay there.
(5) Deposition of the *Obtusum* Nodule-Bed, a thin remanié bed; deposition of the *Raricostatum* Clay.
(6) Renewed uplift in the south, and denudation of varying amounts of earlier deposits.
(7) Deposition of the *Armatum* Bed in the south only, a remanié bed.
(8) Deposition of the *Jamesoni* Limestone, fairly uniformly; further uniform deposition during the formation of the *Striatum* and *Capricornum* Clays.

The paper includes faunal lists and some palæontological notes on the ammonites.

Discussion.

The following is the condensation of a letter sent by Mr. S. S. Buckman, and read in full by the Secretary:—

This is a paper which may confidently be welcomed. The work of the Authors is already well known. Mr. Tutcher has made a lifelong study of the district, and Dr. Trueman has proved his ability as a patæontologist.

One point that this paper should bring out is that of non-sequences; for the Radstock area is one of the best for illustration of this phenomenon. Doubt has been expressed lately as to there being such a phenomenon as non-sequence. This is a very rash position to take up, for, after all, there is no difference, except in degree, between a non-sequence and an uncomformity. In the latter, the stratal discordance is so great as to be obvious at once. In the former, the stratal discordance is so feeble as not to be obvious in one exposure—only to be noted by combining exposures. In the Cotteswolds by this method I found that the inappreciable non-conformity, or as it was called for short, non-sequence, was a discordance or departure from parallelism of 7 feet per mile. The Authors may be able to give similar figures; more likely they may not, because the area described by them does not stretch over many miles like the Cotteswolds.

Those who attack non-sequences write and speak as if 'zone' and 'hemera' were interchangeable terms; and they fail to understand that, knowing from other evidence that there must have been a given interval of time, one is able to point out that the fauna proper to such a time-interval is absent from a given locality. But the fauna is not at all necessary to prove the time-interval. Dr. Lee, for instance, recognizes the time of *niortensis* in the Hebrides, applying the term to a date for an unfossiliferous deposit of some 70 feet.

Another idea which opposes non-sequence is that of a hemera being a short space of time. Geologically it is, relatively it is not. Just as a light-year is the unit of astronomical distance, so is a hemera the unit of geological chronology. What is to prevent us from claiming that a hemera, the unit of geological chronology, is a million years? Faunal development and dispersal in the time of a hemera demand what, to us, is a very long time; but, as compared with the time required for geological history, a million years is a mere nothing.

Dr. W. D. Lang, in joining with the President in welcoming the paper and congratulating the Authors on their lucid exposition,

said that he would like to ask the Authors whether the ammonites of the *A. Turneri* group occurring in the Radstock *Turneri* Clays could be identified with sufficient precision to indicate whether they belonged to the true *A. Turneri* group, occurring in Dorset immediately above *M. birchi*, or to a very similar assemblage of much earlier date, lying, in fact, only a little above the *Euagassiceras* fauna, and separated from the higher zone by several ammonite faunas and some 30 feet of sediment.

The Authors, too, had appeared to imply that the beds of the Dorset-coast Lias were seen to be of a general uniform thickness when traced laterally. This was by no means the case. The '*Striatum* Beds', for instance, which the Authors had discussed in this connexion, varied from more than 100 feet at Westhay to about 60 feet on Stonebarrow, and, so far as could be judged from what remained of them, to considerably less on Black Ven. The speaker suggested that this variation might be partly due to the compression of the clays, if the amount of sediment subsequently piled upon them had varied in different spots.

The paper had brought into prominence the phenomenon of non-sequences, and he wished to protest against the disposition of geologists either practically to deny non-sequences on the one hand, or, on the other hand, to accept uncritically all those that Mr. Buckman demanded. The Authors had demonstrated one non-sequence—that between the lower '*Angulata* Beds' and the upper '*Bucklandi* Beds' (involving a larger gap than those unacquainted with the detailed Lias might suppose), which occurred in the middle of a limestone-band. A non-sequence, as difficult to detect lithically, occurred in the Dorset-coast Lias, one which Mr. Buckman had demanded on palæontological grounds. The speaker had at one time seen no reason for recognizing it, yet now strongly advocated it. On the other hand, he was not prepared to admit some other non-sequences demanded by Mr. Buckman in the Dorset-coast succession. Yet if, in his zeal, Mr. Buckman overstated the case, that was no argument against there being a case to overstate, or against our being grateful to Mr. Buckman for first recognizing the frequency of non-sequences in the Lias; and that there was a strong case for these non-sequences the Authors had fully proved in the present paper.

Dr. L. F. Spath congratulated the Authors on an excellent paper and the Society on receiving a valuable contribution. He welcomed Dr. Trueman's adoption of 'popular' names, as shown in the Abstract, for the purpose of reading and discussing the paper. There was an obvious difficulty, however, in using certain of these terms in an admittedly wrong sense, as the Authors themselves pointed out. He instanced the case of *Ammonites armatus* which was used to designate and give a spurious definition to a bed above the *Raricostatum* Clay, whereas, in reality, this ammonite was of pre-*raricostatus* age.

Dr. A. M. Davies spoke with mixed feelings—thankfulness that the publication of valuable research, expected for many years past, was at last in sight, and regret that the senior Author was

prevented by ill-health from being present. He asked Dr. Trueman whether some of the episodes described might not be due to wider causes than the local movements in the Mendips: derived Echiocerates, for instance, were found in the *jamesoni* zone in the Calvert boring, in an area well outside the Armorican folding. On the general question which had been raised of restricted geographical range *versus* denudation as an explanation of the discontinuous distribution of certain ammonite faunas, every case should be considered on its merits. Where an exceptionally rare and discontinuous fauna came at the top of a series of which each successively lower fauna showed a wider and more continuous geographical range, denudation after gentle folding was the simple and obvious explanation.

Professor H. L. Hawkins laid emphasis on the interest of the work, in that it traced down into the Lias on the northern side of the Mendips conditions of contemporary erosion and folding comparable with those established by Mr. L. Richardson in the Inferior Oolite of the region south of that axis of upheaval. The circumstances seemed strangely complementary, since in the Radstock area the basal 'Sun-Bed' seemed the most persistent and uniform layer in the sequence; while around Doulting and Bruton the Doulting Stone, at the top of the Inferior Oolite, appeared to be the most reliable horizon. It seemed that the district must have been spasmodically unstable from the close of Rhætic to the commencement of Bathonian times. He urged the importance of detailed stratigraphical studies of this nature, in providing clues as to the technique of tectonic movement.

Mr. S. W. Wooldridge said that Mr. Buckman, in his contribution to the discussion, had seen fit to introduce the general question of non-sequences. To deny the existence of non-sequences would be to take up an impossible attitude, but he questioned the validity of a certain class of non-sequences based solely on faunal evidence. The paper to which they had just listened contained convincing evidence of slight angular discordance and erosive breaks to which few would be disposed to deny the term 'non-sequence'. The invisible, or, as the speaker would prefer to term them, hypothetical breaks, were in very different case. Workers on modern zonal stratigraphy seemingly failed to realize that the conception of long-continued and spasmodic sedimentation was not incompatible with rapid accumulation in the unit or bed. The combination of the two ideas certainly implied the existence of many non-sequences, but it also carried other consequences. If a thin sheet of sediment accumulated rapidly over a fairly wide area it might well entomb different faunas at different places. That sediment could so accumulate in a relatively short time was manifest from the study of certain ancient sedimentary rhythms, no less than from the phenomena of recent sedimentation. The explanation of such a case by modern methods would probably necessitate the creation of several non-sequences of the 'invisible' order. How was it possible to be sure that such errors had not crept in, in the case of recent zonal studies?

Mr. G. W. Lamplugh remarked that all clastic sediments were, from their nature, lenticular, though the expansiveness of lenticles of small thickness was often surprisingly great. This might be because, in so many cases, the line of outcrop coincided approximately with the longer axis of the area of deposition. The occurrence locally of long periods of practically uninterrupted sedimentation, for which we had evidence, seemed to the speaker more remarkable than the occurrence of interrupted sedimentation such as the Authors had so ably described. In our current-swept English seas there were few places, except the deep trough between the Isle of Man and Ireland, where continuous local sedimentation could be at present in progress. It was recognized that the area studied by the Authors lay near the margin of the Liassic Sea, and he would ask whether the submarine banking and shifting of sediments might account for the observed phenomena without necessitating the very shallow folding on which they relied.

The President expressed his appreciation of the value of the paper and the interest of the discussion that had followed.

From the tectonic standpoint it was of great importance to make sure whether the non-sequences really corresponded to folding movements. There could be no doubt that these deposits were laid down in a sea with strong tidal currents, which would tend to produce erosion in some areas and accumulations, forming banks, in others. A change of geographical conditions would result in a different system of currents, so that elevations previously formed might be worn away, and ultimately a non-sequence come into existence. On the other hand, the deposition of thick masses of sediments would, in accordance with the principles of isostasy, result in earth-movements which could not well be regarded as a continuation of Hercynian activity.

Dr. Trueman, replying briefly to the points raised in the discussion, said that he did not propose to deal with the criticisms of the principle of dissimilar faunas to which reference had been made. For his own part, ten years ago he attempted to explain discrepancies in the distribution of certain ammonites in the Lias of the Midlands as the result of variations in the physical conditions, but further study of the facts convinced him that such an explanation was untenable.

With regard to Mr. Wooldridge's remarks, he felt that the latter's views were illogical; for he noted that Mr. Wooldridge was prepared to accord a greater length of time to the deposition of the Lias than the thickness of the sediments appeared to require, yet he considered that modern work proved that sedimentation often proceeded more rapidly than had been supposed; presumably, therefore, sedimentation must have been intermittent.

Replying to a question asked by Dr. Lang, Dr. Trueman said that the ammonites of the *Turneri* Clay were badly preserved, but included forms closely resembling those of the upper horizon at Lyme Regis. He had not been able definitely to correlate the Arniocerates.

He agreed with Dr. Spath that there were difficulties in using

such names as *Bucklandi* Bed, *Turneri* Clay, etc., but felt that their use made the general results of the paper available for those unacquainted with more modern Jurassic terminology; he considered that confusion need not arise if it were made clear that the names were so used.

With reference to the point raised by Dr. Davies, doubtless the movements along the Mendip Axis were related to wider movements affecting other regions; nevertheless, he considered that the changes in thickness and in the development of the various beds could only be due to differential movements.

In reply to Mr. Lamplugh, Dr. Trueman said that the distribution of the faunas within such a stratum as the *Raricostatum* Clay made it apparent that the conditions were due mainly to earth-movements and to denudation. The Authors were in substantial agreement with Mr. Lamplugh as to the origin and relations of the phosphatic nodule-beds.

The Authors had considered the possibility of current action suggested by the President, but decided that the distribution of the *Planorbis* and *Angulata* Zones, for example, was too peculiar to have resulted in that way.

Dr. Trueman regretted the absence, owing to ill-health, of his collaborator Mr. Tutcher, but was gratified to hear the kind references to the latter's work. He wished to say that he considered it a great privilege to be associated with Mr. Tutcher in this paper.

The next Meeting of the Society will be held on Wednesday, June 10th, 1925, at 5.30 P.M., when the following communication will be read:—

'On some Occurrences of Spherulitic Siderite and other Carbonates in Sediments'. By Dr. Edmondson Spencer, M.Sc., F.G.S.

Mr. L. R. Cox, B.A., F.G.S., will exhibit fossils and lantern-slides illustrative of the fauna of the basal shell-bed of the Portland Stone (Isle of Portland); and Prof. H. L. Hawkins, D.Sc., F.G.S., will exhibit echinoids from the same bed.

The Society's Apartments are closed, on account of the Whitsuntide Holidays, from the evening of Friday, May 29th, until the morning of Wednesday, June 3rd, 1925.

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ABSTRACTS OF THE PROCEEDINGS

OF THE

GEOLOGICAL SOCIETY OF LONDON.

No. 1137.] June 19th, 1925. [Session 1924–25.

June 10th, 1925.

Dr. J. W. Evans, C.B.E., F.R.S., President, in the Chair.

Major Frank Hibbert, M.C., R.E.(T.), A.M.Inst.C.E., Waterworks Engineer, Swansea Corporation, Norbury, Queen's Road, Sketty, Swansea; John George Anthony Skerl, M.Sc., Department of Applied Science in the University of Sheffield, St. George's Square, Sheffield; and James Wright, Bellevue, Beveridge Road, Kirkcaldy (Fife), were proposed as Fellows of the Society.

The List of Donations to the Library was read; it included, among others, the following works:—Memoirs of the Geological Survey of England & Wales—'The Geology of the Country around Marlborough', by H. J. O. White, 1925; 'Handbook of the Geology of Ireland', by G. A. J. Cole & T. Hallissy, 1924, and 'The Earth, its Origin, History, & Physical Constitution', by H. Jeffreys, 1924 (both presented by the President); Geological Survey of South Africa, Memoir No. 19—'The Coal Resources of the Union of South Africa, vol. ii: The Inland Coalfields of Natal', by W. J. Wybergh, 1925; 'The Data of Geochemistry', 5th ed., by F. W. Clarke, 1924; Bulletin de la Commission Géologique de Finlande, No. 70—'The Average Composition of the Earth's Crust in Finland', by J. J. Sederholm, 1925; 'The Correlation of the Coal Measures in the Western Portion of the South Wales Coalfield: Part III—The Upper Part of the Pennant Series of the Swansea District', by T. H. Rowlands, 1925; 'Studii Geologici sul Monte Pisano', by A. Fucini, 1925; Supplement to the Journal of Geology, vol. xxxiii—'The Analysis of Gases obtained from Volcanoes & from Rocks', by E. S. Shepherd, 1925; 'Observations on Fossil Vegetables, Accompanied by Representations of their Internal Structure, as seen through the Microscope', by H. T. M. Witham, 1831, and 'The Internal Structure

of Fossil Vegetables found in the Carboniferous & Oolitic Deposits of Great Britain', by H. T. M. Witham, 1833 (both presented by Prof. W. T. Gordon); and 1-inch Geological Survey map of England & Wales, Sheet 256, North London, drift, 1925.

Mr. Leslie Reginald Cox, B.A., F.G.S., exhibited specimens and lantern-slides illustrating the Fauna of the basal Shell-bed of the Portland Stone of the Isle of Portland. He stated that the fossils exhibited were collected by Lt.-Colonel R. H. Cunnington, R.E., of Weymouth, during the past year.

On the western coast of the Isle of Portland the basal bed of the Portland Stone is a highly fossiliferous shelly limestone, on the surface of which fossils weather out in an extremely good state of preservation. Owing to the comparative inaccessibility of the exposures, the fauna of this bed has not previously been investigated in detail. The specimens collected by Colonel Cunnington include about 80 species of mollusca, of which 18 lamellibranchs and 9 gastropods are new to science, and several others have not before been recorded from this country. A study of these fossils has, therefore, added considerably to our knowledge of the English Portlandian fauna.

A description by the exhibitor of the mollusca, and by Dr. W. D. Lang of the polyzoa, is now in course of publication in the Proceedings of the Dorset Natural History & Antiquarian Field-Club.

Prof. Herbert Leader Hawkins, D.Sc., F.G.S., exhibited a series of Echinoidea from the Portland Stone and the Purbeck Beds, and explained that the specimens had a peculiar interest by reason of their rarity and good preservation. Before last year only one species (*'Echinobrissus' brodiei* Wright) was known from the Portland stone, and this form was represented by very few examples, mainly collected in Buckinghamshire. A species of *Hemicidaris* from the sands was the only other Echinoid recognized in the British Portlandian. The work of Lt.-Colonel Cunnington has revealed three excellent specimens of *'E.' brodiei* in the basement-bed of the Portland Stone (and one from the overlying Whit-Bed); and, in addition, adequate material for the study of four other species, with indication of a sixth. The collection from the basement-bed comprises 21 specimens, which may be classed provisionally as follows:—

Tetragramma sp nov. A.	2 specimens.
Tetragramma sp. nov. B.	10 do.
Trochotiara thirriai (Étallon) var. nov.	3 do.
Trochotiara sp. nov.	1 do.
(?) *Trochotiara* sp. indet. (radiole).	1 do.
Hemicidaris sp. indet. (radiole).	1 do.
Clitopygus brodiei (Wright).	3 do.

Trochotiara thirriai is a well-known form from the Portlandian of Northern France. The occurrence of two well-marked species of *Tetragramma* is interesting. This genus is essentially of

Cretaceous date, only two species having been recorded from Jurassic strata. Species B shows some resemblance to one of these, the imperfectly known *T. rougonense* (Cotteau); but species A has an almost Cenomanian aspect. All of the forms will be described and figured at an early date.

At the same time Prof. Hawkins introduced to the Fellows the results of a search made by himself in the Middle Purbeck Series of Durlston Bay, near Swanage, in the summer of 1924. *Hemicidaris purbeckensis* Forbes (which was collected from that locality about 75 years ago) has not been recorded from England since its first discovery, although it is well known in France. He collected 38 tests (mostly crushed, but otherwise complete) and innumerable detached plates and radioles, in the course of a few days, no fewer than 14 tests being extracted in a single hour. In addition, two specimens of an apparently new form referable to '*Pseudodiadema*' *sensu latissimo* rewarded his efforts. Thus, in the course of a few months, after a delay of three-quarters of a century, the Echinoid fauna of the Portland Stone has been increased sixfold and that of the British Purbeck Series has been doubled; while the number of specimens now known from both horizons has been enormously multiplied.

The speaker commented on the extremely irregular distribution of Echinoids in these and other Jurassic strata—a distribution which leads to such strange anomalies in collecting as those indicated by the exhibit now shown. He suggested that the irregularity might be ascribed to the known tendency of Echinoids to live in restricted clusters (comprising several species of similar ecological quality), which seem to migrate wholesale in successive generations. This explanation seemed more probable than any alternative based on *post-mortem* segregation of empty tests by the action of currents, since in general the specimens were exquisitely preserved, and often retained their radioles and masticatory apparatus.

The following communication was read:—

'On some Occurrences of Spherulitic Siderite and other Carbonates in Sediments'. By Edmondson Spencer, B.Sc., Ph.D., F.G.S.

The Author gives descriptions of a number of spherulitic aggregates (many of which have been described as oolitic) in freshwater clays and in coals. The occurrences, which are considered in detail, include those in the Fairlight Beds, the Upper Coal Measures of Staffordshire and South Wales, the Upper Wankie Sandstone Series (Rhodesia), and the coals of the Damuda Basin (India). For comparison with these, spherulites with radiolaria from Santo Domingo (Portugal) are described.

The spherulites are composed of rhombohedral carbonates,

usually siderite, but occasionally of calcite, sideroplesite, dolomite, or a mixture of manganese and iron carbonates (as at Santo Domingo). By treating thin slides of the spherulitic siderite (after heating to redness) with warm hydrochloric acid and stannous chloride, the iron is removed and the structure, as outlined by occluded sedimentary material (such as clay or coal), may be studied.

Certain common characters are observed: (1) The spherulites occur in association with fine-grained sediments of carbonaceous, muddy, or silty type, often with comminuted plant-tissue; (2) the deposits seem, without exception, to be of freshwater origin and devoid of calcareous shelly remains; (3) the carbonate material in most cases consists of nearly pure siderite, with a little carbonate of magnesium and calcium (usually in dolomite-proportions); (4) the spherulites are fairly uniform in size locally: the smallest series has a diameter of about 0·5 mm. and the largest series 2 to 3 mm.; (5) the occluded sediment is similar to that in which the spherulites are embedded, and has been enclosed during their growth; and (6) where 'zoning' of the sediment occurs, it is subordinate to radial structure.

It is concluded that the spherulites have formed from iron-carbonate solutions held within the gradually settling and consolidating sediment. The contrast in the character of carbonate chemically precipitated from solution (as in the blackband and clay-ironstones) is noted.

The reactions resulting from the presence in sediments of humate compounds, salt, calcium carbonate, etc. are considered. The Author believes that the iron compounds present in solution in fresh water as carbonates, humates, or hydrolized and possibly colloidal hydrates, were adsorbed by the fine-grained and partly colloidal sediments, and were carried down with them during deposition. Conditions of supersaturation would result from the settling and flocculation of the sediment, and from the gradual upward expulsion of the more readily diffused water-molecules. Crystallization would then commence at a number of centres simultaneously, the spherulitic growth ceasing before the consolidation of the sediment was completed. Comparisons are instituted with well-known diffusion phenomena in colloidal media resulting in the production of 'zoning'.

Interfering surfaces between adjoining spherulites are mostly plane, but occasionally are slightly concave to the smaller individuals.

In an Appendix, the Author discusses mathematically the form of the surface of contact between spherulites, as determined by various rates of growth.

Discussion.

Mr. A. F. Hallimond said that it was most interesting to have a comparison of the foreign sphærosiderites with the well-known English examples. Coal-measure ironstones were, broadly speaking,

of three types: fine-grained siderite mudstones, peculiar carbonate rocks which sometimes occupied the position of coal-seams (like that from Wirral described by Sir Aubrey Strahan), and sphærosiderites. The formation of the latter was attributed by the Author to adsorption, but it was difficult to imagine any conditions in which the 70 to 80 per cent. of ferrous carbonate in a rich sphærosiderite could be adsorbed by 30 to 20 per cent. of siliceous clay. We could not at present go much farther than to say that, by some means, the clay was supplied from without with a solution that became more than saturated with respect to siderite, and that precipitation occurred round nuclei, usually very numerous, which under certain conditions were rarer and gave rise to sphærosiderites. The spherulitic form resulted from a special kind of nucleus, and the conditions for spherulitic growth from solutions had been investigated experimentally in a series of papers published of late years in the Bulletin of the French Mineralogical Society. Some English sphærosiderites had been described by the speaker in a newly published volume of the 'Special Reports' of the Geological Survey (vol. xxix) on the bedded iron-ores. He regretted that the distribution of this Memoir had been stopped on account of the bad printing of four of the plates, but he hoped that the Stationery Office would be able to supply copies in a good state in the course of a few days. Meanwhile a copy was exhibited on the table.

The leached and stained microsections afforded a very beautiful demonstration of the distribution of the included clay matter in the spherules. For the detection of siderite itself, with the assistance of Mr. R. Sutcliffe, of the Geological Survey Laboratory, he had succeeded in obtaining a method of staining siderite without destroying the calcite. The polished face of the chip was immersed for a few minutes in boiling strong caustic potash solution, to which a little hydrogen peroxide was added at intervals. This gave a remarkably uniform brown stain all over the siderite surfaces, and the chip could be washed and the section completed in the usual way. Mr. Hallimond then exhibited microsections of sphærosiderites and of rocks stained by the above method.

Mr. A. O. Hayes said that he had studied the occurrence of siderite in the Wabana iron-ore of Newfoundland thirteen years ago, and as these are hæmatite-deposits of marine origin, it may be of interest to compare and contrast briefly the freshwater and the marine types.

The Wabana iron-ore deposits, belonging to the British Empire Steel Corporation, form the largest known single reserve in the British Empire. They are of Ordovician age, and their similarity to certain oolitic hæmatite-deposits in Wales of Arenig age, as well as a marked resemblance of some portions to the Cleveland ores, has been described by Mr. Hallimond in his recently published report on the Iron-Ores of Great Britain.

While the general character of the Wabana iron-ore is hæmatitic, in the upper part of a bed 7 feet thick the oolitic hæmatite is

capped by oolitic siderite and chamosite several inches thick. Siderite occurs interstitially in smaller quantity throughout the upper half of the bed.

The siderite is associated with oolitic chamosite, a hydrated ferrous silicate of iron and magnesia, and the latter has been partly destroyed, with (in some places) pseudomorphs of siderite retaining the oolitic form of the chamosite. No original oolitic siderite was observed, and the speaker concluded that the chamosite, which forms an integral part of all the ore, was deposited, to some extent at least, before the hæmatite and siderite were precipitated in the sea-bottom deposits.

The large quantity of decaying organisms, including annelids, trilobites, and bivalves, mainly *Lingulæ*, which undoubtedly were partly buried in the soft iron silicate and hæmatite ooze, would supply carbon dioxide: this may have given rise to the formation of the iron carbonate, and would explain its destructive action in replacing the silicated iron.

Thus, under the special conditions obtaining in these marine deposits, no tendency for the siderite to adopt a spherical form was observed, in contrast with the examples cited from the coals and freshwater deposits.

Mr. A. Broughton Edge also spoke.

In addition to the exhibits described on pp. 86–87, specimens of spherulites from various formations were exhibited in illustration of Dr. Edmondson Spencer's paper.

The next Meeting of the Society will be held on Wednesday, June 24th, 1925, at 5.30 p.m., when the following communications will be read:—

1. 'A Sagittal Section of the Skull of *Australopithecus africanus*'. By Prof. W. J. Sollas, M.A., Sc.D., F.R.S., F.G.S.
2. 'The Faunal Succession in the Carboniferous Limestone and Bowland Shales at Clitheroe and Pendle Hill'. By Donald Parkinson, B.Sc., F.G.S.
3. 'On *Cyathoclisia*, a New Genus of Carboniferous Corals'. By Miss J. M. M. Dingwall, M.A., B.Sc., F.G.S.

Albert George Brighton, B.A., Christ's College, Cambridge; Percy Harrison, F.S.I., Borough Engineer & Surveyor, High Barn, Alkrington, Middleton (Lancashire); and Joseph Slomnicki, A.R.S.M., Geologist, c/o Steaua Romana, Campina (Rumania) will be balloted for as Fellows of the Society.

Prof. William Morris Davis, Library Museum, Cambridge (Massachusetts); and Dr. Gerhard Holm, Geological Survey of Sweden, Stockholm, will be balloted for as Foreign Members of the Society.

Prof. Paul Lemoine, Paris; Dr. Victor Madsen, Copenhagen; Prof. Paul Niggli, Zürich (Switzerland); Prof. Josef Felix Pompeckj, Berlin; Dr. T. Wayland Vaughan, Washington (D.C.), U.S.A.; and Dr. Mikhail Dimitrivich Zalessky, Petrograd, will be balloted for as Foreign Correspondents.

Erratum.

In Abstract No. 1136, June 2nd, 1925, p. 78, lines 9 & 10 from the bottom, *for* 'step-like fracture', *read* 'step-like feature'.
On the same page, line 6 from the bottom, *for* 'scoured', *read* 'scored'.

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ABSTRACTS OF THE PROCEEDINGS

OF THE

GEOLOGICAL SOCIETY OF LONDON.

No. 1138.] **July 4th, 1925.** **[Session 1924–25.**

June 24th, 1925.

Dr. J. W. Evans, C.B.E., F.R.S., President, in the Chair.

Albert George Brighton, B.A., Christ's College, Cambridge; Percy Harrison, F.S.I., High Barn, Alkrington, Middleton (Lancashire); and Joseph Slomnicki, A.R.S.M., c/o Steaua Romana, Campina (Rumania), were elected Fellows of the Society.

Prof. William Morris Davis, Library Museum, Cambridge (Massachusetts); and Dr. Gerhard Holm, Geological Survey of Sweden, Stockholm, were elected Foreign Members of the Society.

Prof. Paul Lemoine, Paris; Dr. Victor Madsen, Copenhagen; Prof. Paul Niggli, Zürich (Switzerland); Prof. Josef Felix Pompeckj, Berlin; Dr. Thomas Wayland Vaughan, La Jolla (California), U.S.A.; and Dr. Mikhail Dimitrivich Zalessky, Petrograd, were elected Foreign Correspondents of the Society.

The Names of certain Fellows of the Society were read out for the first time, in conformity with the Bye-Laws, Sect. VI., Art. 5, in consequence of the non-payment of the arrears of their Annual Contributions.

The List of Donations to the Library was read; it included, among others, the following works:—Special Reports on the Mineral Resources of Great Britain, vol. xxix—'Iron-Ores: Bedded Ores of England & Wales—Petrography & Chemistry', by A. F. Hallimond, with an Appendix by F. R. Ennos & R. Sutcliffe, 1925; Ministry of Agriculture & Fisheries: 'The Marine Deposits of the Southern North Sea', by J. O. Borley, 1923; 'Observations sur la Structure du Cap Gris-Nez et sur les Mouvements qui ont affecté le Pays Boulonnais après le Dépôt du Jurassique', by P. Pruvost, 1925; 'The Physical Chemistry of the Magmatic Differentiation of Igneous Rocks', by J. H. L. Vogt, 1924; 'The Geology of Ascension Island', by R. A. Daly,

1925; Bulletin of the U.S. Geological Survey, No. 760 C: 'Erosion by Solution & Fill', by W. T. Lee, 1925; and Geological Survey of Egypt: 'The Geography & Geology of Makalla (South Arabia)', by O. H. Little, 1925.

The following communications were read:—

1. 'On a Sagittal Section of the Skull of *Australopithecus africanus*.' By Prof. William Johnson Sollas, M.A., Sc.D., F.R.S., F.G.S.

The Author, after comparing sagittal sections of the skulls of the Anthropoid Apes, the Hominidæ, and the Taungs skull, concludes that the last-named presents numerous and important characters, by which it differs from the Anthropoids and makes some approach towards the Hominidæ.

He considers that his observations fully justify the claims of *Australopithecus* to generic distinction.

Discussion.

Prof. D. M. S. Watson said that what little he knew of the Taungs skull was derived from the examination of a cast that had now been sent to the Wembley Exhibition. The skull was quite undistorted and extraordinarily narrow. It was different from that of all other great Apes, yet wonderfully human in appearance, in dentition, etc. The brain-cast had impressed all neurologists by its very human appearance. The Taungs skull was that of an Ape more like Man than any other Ape yet known. The only other mammalian remains found with it were skulls of baboons and a jaw of *Hyrax*, inhabitants of unforested regions. Giant Apes, on the other hand, were essentially forest animals, and the loss of the arboreal habit was the first step in the transition from Ape to Man.

Dr. A. W. Rogers said that South African geologists would be much interested to hear the Author's opinion of the skull. He agreed with Prof. Watson that there was no probability of the age of the deposit being determined, pointing out that the tufa had formed on the face of a limestone escarpment of Carboniferous date flanking the old Kaap Valley (named by Dr. A. L. du Toit) which had been filled by Carboniferous and later sediments (Karroo Beds) and re-excavated. The re-exposure of the escarpment commenced perhaps in Cretaceous times, and the deposition of tufa had varied greatly in amount and in its distribution. The part of the deposit, a limestone-cemented wash on drift, in which the skull lay, is said to have been some 60 feet behind the face of the quarry.

A description of the deposits, by Prof. R. B. Young, is being published by the Geological Society of South Africa.

The Author expressed his thanks to the Society for their reception of his paper, and his satisfaction at the additional confirmation of Prof. Dart's discovery by Prof. Watson. He might

recall that, on a former occasion, in the course of a Presidential Address, he had himself asserted that the first step in human evolution was probably the emancipation of some members of the Primates from the enchantment of the forest, and their issue as beasts of prey on to the plains. That the Taungs ape lived in Southern Rhodesia when that region was devoid of forests, and was thus a denizen of the plains, was now vouched for as a fact by Dr. Rogers, than whom there could be no higher authority.

2. 'The Faunal Succession in the Carboniferous Limestone and Bowland Shales at Clitheroe and Pendle Hill.' By Donald Parkinson, B.Sc., F.G.S.

The rocks described form that portion of the south-eastern limb of the Clitheroe Anticline which is included between the Twiston and Clitheroe Faults, along with most of the scarp-face of Pendle Hill.

The succession is as follows:—

Strata.	Zones and Sub-zones.		Approximate thickness in feet.
Pendle Grit.			
Bowland Shales.	*Homoceras leion (?)*		50
	Eumorphoceras pseudobilingue		400
	Goniatites spirale	P_2	250
	Goniatites sphæricostriatus	P_1	600
Pendleside Limestone Series.	*Emmonsia parasitica*	D_2	40
	Lithostrotion araehnoideum	D_2	260
	Beyrichoceras hodderense	D_1	300
Worston Shale Series.	*Prolecanites compressus*	D_1 ?	1100–1600
Clitheroe Limestone. Salt Hill Knoll Series.	*Pustula ovalis*	S.	900–1400
Coplow Knoll Series.	*Spirifer subcinctus*	C.	400
Chatburn Limestone.	*Pustula nodosa*	Z–C_1	700+ Base not seen.

The lowest beds appear to be of Z age, but the junction of Z and C is an uncertain horizon. The Coplow Knoll Series is of similar facies to the C zone of County Clare, and the Waulsortian of Belgium. The knoll-limestones pass laterally into shales and crinoidal limestones. The Salt Hill Series, of S age, shows similar lateral variations. The knolls of this group are finely developed, and one (Worsaw) is about 1400 feet thick.

The Worston Shale Series, of probable D_1 age, includes most of the 'Shales-with-Limestones' of the Geological Survey maps. It is overlain by the *hodderense* goniatite-band, which forms a constant feature along the foot of Pendle Hill.

The Pendleside Limestone proper contains an Upper D coral-brachiopod fauna, with *Goniatites crenistria* at the top. The Lower Bowland Shales with *G. sphæricostriatus* and *Posidonomya becheri* succeed, and these beds are correlated with P_1 of Loughshinny and with the Lower Yoredale Series. It appears probable that the beds usually referred to Lower P are in reality of D_2 age.

The *Spirale* Zone is correlated with P_2 of Loughshinny. The

Pseudobilingue Zone terminates below the Pendle Grit, where another goniatite (possibly *H. leion*) appears, and forms a continuous horizon just below the grit. It is suggested that the base of the Upper Carboniferous should be drawn here.

The nature of the junction of the Worston Shales with the knoll-limestone is discussed. The shales appear to have been deposited on a very uneven sea-floor, the irregularities being due to the mode of accumulation of the limestones, and not to interformational uplift and erosion. This, and other evidence, lends support to Tiddeman's theory of the origin of reef-knolls.

The paper contains faunal lists, and palæontological notes on some of the corals and brachiopods.

Discussion.

Prof. E. J. Garwood welcomed this paper as a much-needed contribution to the geology of the district south of the Craven Faults. He asked the Author whether the fauna of the Coplow Knoll Series differed essentially from that of the Salt Hill Knoll Series, and whether the fauna of the latter differed essentially from that of the Cracoe knolls. He agreed with the Author that this type of knoll-structure was due to the original mode of deposition, but would like to ask whether there was any evidence that the knoll-structure had been subsequently emphasized by earth-movements. He also enquired whether the overlying Worston Shale Series could be seen to be deposited earlier in the depression between the knolls, so that only higher horizons were seen in contact with the top of the knolls. He asked whether there was any trace of an unconformity at the base of the Bowland Shales: in the Bordley district between the Craven Faults these shales appeared to abut against different horizons of the Northern Succession, while in the Scaleber area the shales overlying the knolls contained *Eumorphoceras pseudobilingue*, the lower beds being apparently absent. He felt sure that the careful work done by the Author in the Clitheroe district would be warmly appreciated by workers in the Lower Carboniferous rocks.

Dr. A. Wilmore, as one who had worked in the area for many years, joined in congratulating the Author on a careful piece of zonal work. He was particularly interested to learn that the Author accepted the lower beds of Chatburn as belonging to Z. He (the speaker) had had the privilege of showing these beds to the late Dr. A. Vaughan, who had previously hesitated to believe that any beds so low in the series could possibly occur. He now suggested to the Author that a well-marked bed containing *Zaphrentis omaliusi*, var. *ambigua* R. G. Carruthers, might serve as a local datum-line dividing the Z and C zones. This horizon could be traced for many miles between Skipton and Clitheroe.

He was also interested to learn that the Author recognized the value of the Ravensholme Limestone as an important palæontological horizon in the lower part of the Pendleside Limestones. He (the speaker) had found this horizon over a very wide area.

The Stonyhurst workers had also traced it at many points in the Bowland area.

He doubted whether the Author had given due weight to the effects of the post-Carboniferous movement and of the long-continued denudation in producing the present topography of the knolls. The evidence of folding is very widespread in the 'Shales-with-Limestones' near the knolls. Irregular 'knoll-bedding' is obvious in the Clitheroe knolls, as elsewhere in the mid-Pennine region, but well-defined quaquaversal dips are rare.

Prof. W. S. Boulton wished to testify to the great care and skill shown by the Author throughout the investigation, a summary of which they had just heard. The classification of the Carboniferous rocks is still in a state of flux, and the Author had made a valuable contribution towards fixing a sound classification for the North of England. In that connexion it was comforting to note that the suggested palæontological boundary between the Upper and the Lower Carboniferous is a line that can be mapped at the base of the Pendle Grit. It would be found that the Author's results support the view that the reef-knolls are due to peculiar conditions of limestone accumulation in a sinking area, rather than to subsequent tectonic disturbances.

Dr. Stanley Smith expressed his interest in the paper and his appreciation of the quality of the work. He asked the Author whether he intended the '*Posidonomya* Zone, P_1' to replace D_3 or whether he inferred a non-sequence. In any case, it would be advisable to consider the abandonment of the name for that of the goniatite characteristic of the horizon, since the term '*Posidonomya* Zone' had been used for beds assumed to succeed D_3, but really implied a facies which can occur at various horizons.

Mr. R. G. S. Hudson commented on the special interest of the paper to him, because he had been working on a similar succession immediately south of the Cracoe knolls. He enquired as to the thickness of the individual beds, because he could parallel the faunal succession (as given by the Author) zone by zone with that of the Skelterton district, but there the beds were remarkably thin. The *Emmonsia-parasitica* Beds are 8 feet thick, instead of 40 feet; the Lower Bowland Shales are about 80 feet thick, instead of 850 feet as at Pendle, and so on.

He also remarked on the evidence put forward showing the lateral passage of the Clitheroe knolls into thinly-bedded limestones. The Skelterton knoll shows exactly the same passage into thinly-bedded limestones, which are here of Pendleside-Limestone age and have the same faunal sequence as at Pendle.

He supported the general correlation of the Cracoe knolls with the Pendleside Limestone Series, but was inclined to think that the Cracoe knolls were on slightly different horizons and probably equivalent to the various levels of the Pendleside Limestone or even of part of the *Goniatites-sphæricostriatus* Zone.

The Author, in reply to Prof. Garwood, stated that, although the Coplow and Salt Hill knolls contained many species in common,

the fauna for the greater part was distinct at the two horizons. He did not think that the structure of the Clitheroe knolls had been very appreciably modified by earth-movements subsequent to their deposition. With regard to the overlap of the Worston Shales on the knoll-limestone, the evidence provided by the goniatites, although at present slight, supported the field evidence that different members of the shale series rested upon the limestone. There was no evidence of a break at the base of the Bowland Shales on Pendle Hill, the latter appearing to succeed the Pendleside Limestone quite normally.

In reply to Dr. Stanley Smith, the Author stated that he had retained the use of the symbol P_1 for beds apparently no higher than D_2, because he did not as yet know the horizon on Pendle Hill corresponding to the top of D_2 elsewhere.

He was greatly interested in Mr. Hudson's remarks, and glad to know that the Pendle sequence could be paralleled in the Craven district.

The following contributions to the Discussion were received by the Secretaries after the Meeting:—

Mr. W. B. Wright wrote that it was with feelings of keen interest that he looked forward to the publication of the paper. The area presents what appears to be an unbroken stratigraphical passage from the Lower to the Upper Carboniferous, and basal members of the Upper Carboniferous appear to be present here, which are absent in other parts of England. The Author had, he was glad to see, made good use of Mr. W. S. Bisat's goniatite zones in the subdivision of the succession. One must presume, therefore, that the Author had definite reasons for placing the base of the Upper Carboniferous at a higher level than that adopted by Mr. Bisat, that is, in the middle of the zone of *Eumorphoceras* instead of at its base. The base of the *Eumorphoceras* Zone seems to coincide with the marked faunal break between *Goniatites* proper and the higher genera, and is on this account to be preferred to another line, no matter how well defined or easily traceable the latter may be locally.

Besides, *Homoceras leion* was, the writer understood, an undescribed form. Geologists in the Lancashire district, who have been using the name conversationally as a matter of convenience, will welcome its description and the establishment of its zonal significance. Even then, however, they will require very cogent reasons for regarding it as the base of the Upper Carboniferous. Mr. Bisat's subdivision has been adopted by the Lancashire unit of the Geological Survey, and, although this in no sense renders it sacrosanct, any divergence will make it still more difficult for those not in touch with the intricacies of the problem to extract an intelligent meaning from the literature.

Mr. E. E. L. Dixon wrote to congratulate the Author on the successful completion of a most important and arduous piece of

work. The sequence is difficult to correlate, because the rocks are wholly 'phasal' deposits, consisting of reef-limestones, Zaphrentid phases, and goniatite- and lamellibranch-beds. Hence the importance of fixing the points, on the Avonian time-scale, of the deposition of the oldest limestones exposed in this area, of the period or periods of formation of the reef-limestones, of the various goniatite-beds, and of the much-debated Pendleside Limestone.

Now that later evidence obtained elsewhere in Britain and in Belgium has demonstrated the essential truth of Tiddeman's theory of the origin of reef-limestones, the next step was to ascertain whether these reefs have a bearing on the theories of coral-reef formation that are occupying the attention of Prof. W. M. Davis and Dr. T. Wayland Vaughan.

Thanks to the work of Wheelton Hind and W. S. Bisat, the goniatite-beds have been transformed from a hindrance to correlation into a great help. Characteristic, on the whole, of Upper Carboniferous marine deposits, they nevertheless enter in Lower Carboniferous times and at different dates in different places. As they and 'standard' coral-and-brachiopod limestones are mutually exclusive, they need a zonal time-scale, with symbols of their own, parallel to and, where possible, correlated with the time-scale based on standard faunas. The writer suggested that P should be dropped as a time-symbol, and distinctive symbols adopted for all goniatite-zones. Thus, those of the area now described would not be indicated either by D_1, a symbol of 'standard' limestones, or by P, but, say, by Pc (*Prolecanites compressus*), Bh (*Beyrichoceras hodderense*), etc.

The question of the dividing line between the Lower and the Upper Carboniferous involves consideration of other areas, in which conditions of sedimentation near the junction have been less uniform than in that now described. Evidence is accumulating that the unconformity between the Millstone Grit and the Carboniferous Limestone, first recognized in Pembrokeshire by Prof. O. T. Jones, is widespread, and the oldest deposits formed after this earth-movement should be taken as the base of the Upper Carboniferous.

In conclusion, the writer asked the Author to add to our indebtedness by throwing some light, if possible, on the cause of the development of goniatite-beds as against deposits with an abundant fauna of brachiopods and corals.

3. '*Cyathoclisia*: a New Genus of Carboniferous Corals.' By Miss Janet Mitchell Marr Dingwall, M.A., B.Sc., F.G.S.

This paper describes certain Tournaisian corals of limited range, which are fairly abundant in certain localities in the South-West of England and South Wales. These forms agree with *Clisiophyllum* in their general features, but differ so markedly from the Viséan species of the genus in structural details that it

has been deemed desirable to assign to them a new generic name. The name *Cyathoclisia*, suggested by Dr. W. D. Lang, is here adopted. The new genus includes forms previously described by Arthur Vaughan as *Cyathophyllum*.

The members of this genus are simple rugose corals, with a characteristically smooth epitheca. The calyx is deep, and from the floor rises a sharp spine-like central column. There is a well-developed central area, an intermediate zone of tabellæ, and an outer zone of dissepiments. The major septa are numerous, and are almost invariably continuous from the epitheca to the centre. A short, but often strongly thickened, medial plate is usually present. There is a well-developed fossula, occupied by a long cardinal septum. The tabellæ of the central area are much more numerous, and more steeply inclined, than in the intermediate area.

One species—*Cyathoclisia tabernaculum*—is described in detail, along with its developmental stages. The remarkable variability of the species is discussed, and variations are described; but it has not been found necessary to create more than one species.

Cyathoclisia tabernaculum appears to have a limited distribution, both horizontally and vertically. So far as is known, it is confined to the South-Western Province of the Carboniferous Limestone. It appears suddenly in the γ beds and then as quickly disappears, although a few isolated individuals linger in C.

Cyathoclisia is contrasted with *Clisiophyllum* and *Palæosmilia (Cyathophyllum)*, and its affinities are discussed. It is probable that in *Cyathoclisia* and *Clisiophyllum* we have an example of parallel developments, and the time of its appearance and the similarity of structure suggest that *Cyathoclisia* may have been developed from *Palæosmilia*.

Discussion.

Dr. Stanley Smith congratulated the Authoress upon a detailed piece of work which contributed greatly to our knowledge of Carboniferous corals. He emphasized the differences between *Cyathoclisia* and *Clisiophyllum*, and pointed out that in longitudinal section *C. tabernaculum* very closely resembled Dana's original figure of *Clisiophyllum*. Since, however, the species figured has neither name nor locality, we were driven to take one of M'Coy's species as the genotype of *Clisiophyllum*.

Dr. W. D. Lang joined with the former speaker in his congratulations to the Authoress on her careful and thorough investigation, and expressed his satisfaction that, after many years, the form, or rather, group of forms, which she described, had now received a generic name.

He was inclined to regard the resemblances, on which the Authoress had dwelt, between *Cyathoclisia* and similar genera, especially *Clisiophyllum*, as having no close genetic significance, but rather as being expressions of similar trends in genetically distinct stocks. He regretted that the Authoress had not had time

to explain in detail the ontogeny which she had so carefully worked out, or to compare this ontogeny with that of the comparable genera. It was here, he thought, that the significant generic differences should be sought: that was to say, in differences of detail in the way that generally similar structures had been built. He thought that it would be found that these differences were caused by different rates of development of the different characters along generally similar lines.

He much hoped that the paper would soon be available for leisured study.

Specimens from the Clay Pebble-Bed of Ancon (Ecuador) were exhibited by Mr. C. Barrington Brown, M.C., M.A., F.G.S.

The next Ordinary General Meeting of the Society will be held on Wednesday, November 4th, 1925.

No. 322 of the Quarterly Journal, Part 2 of Vol. LXXXI for 1925, contains, in addition to the President's Anniversary Address, the following papers:—

5. Prof. J. E. Marr on the Conditions of Deposition of the Stockdale Shales of the Lake District.
6. Miss M. E. Tomlinson on the River-Terraces of the Lower Valley of the Warwickshire Avon.
7. Mrs. E. G. Woods and Miss M. C. Crosfield on the Silurian Rocks of the Central Part of the Clwydian Range.
8. Dr. F. Dixey on the Geology of Sierra Leone.
9. Mr. F. Raw on the Development of *Leptoplastus salteri* and of other Trilobites.
10. Miss E. M. Guppy & Mr. L. Hawkes on a Composite Dyke from Eastern Iceland.

The List of Geological Literature added to the Society's Library for 1924 (No. 27) is now issued. The subscription rate to Fellows is 2*s*. 6*d*.

The Society's Apartments will be closed, as usual, for the Annual Cleaning, during the fortnight beginning on Monday, September 7th. Books borrowed from the Library must be returned before that date.

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